OpenShift Container Platform 4.16

Edge computing

Configure and deploy OpenShift Container Platform clusters at the network edge

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Abstract

This document describes how to configure and deploy OpenShift Container Platform clusters using GitOps ZTP to provision and manage sites at the far edge of the network.

Table of Contents

CHAPTER 1. CHALLENGES OF THE NETWORK FAR EDGE **9**
- 1.1. OVERCOMING THE CHALLENGES OF THE NETWORK FAR EDGE 9
- 1.2. USING GITOPS ZTP TO PROVISION CLUSTERS AT THE NETWORK FAR EDGE 10
- 1.3. INSTALLING MANAGED CLUSTERS WITH SITECONFIG RESOURCES AND RHACM 11
- 1.4. CONFIGURING MANAGED CLUSTERS WITH POLICIES AND POLICYGENTEMPLATE RESOURCES 12

CHAPTER 2. PREPARING THE HUB CLUSTER FOR GITOPS ZTP **15**
- 2.1. TELCO RAN DU 4.16 VALIDATED SOFTWARE COMPONENTS 15
- 2.2. RECOMMENDED HUB CLUSTER SPECIFICATIONS AND MANAGED CLUSTER LIMITS FOR GITOPS ZTP 16
- 2.3. INSTALLING GITOPS ZTP IN A DISCONNECTED ENVIRONMENT 17
- 2.4. ADDING RHCOS ISO AND ROOTFS IMAGES TO THE DISCONNECTED MIRROR HOST 18
- 2.5. ENABLING THE ASSISTED SERVICE 19
- 2.6. CONFIGURING THE HUB CLUSTER TO USE A DISCONNECTED MIRROR REGISTRY 20
- 2.7. CONFIGURING THE HUB CLUSTER TO USE UNAUTHENTICATED REGISTRIES 23
- 2.8. CONFIGURING THE HUB CLUSTER WITH ARGOCD 24
- 2.9. PREPARING THE GITOPS ZTP SITE CONFIGURATION REPOSITORY 26
- 2.10. PREPARING THE GITOPS ZTP SITE CONFIGURATION REPOSITORY FOR VERSION INDEPENDENCE 29

CHAPTER 3. UPDATING GITOPS ZTP **32**
- 3.1. OVERVIEW OF THE GITOPS ZTP UPDATE PROCESS 32
- 3.2. PREPARING FOR THE UPGRADE 32
- 3.3. LABELING THE EXISTING CLUSTERS 33
- 3.4. STOPPING THE EXISTING GITOPS ZTP APPLICATIONS 34
- 3.5. REQUIRED CHANGES TO THE GIT REPOSITORY 34
- 3.6. INSTALLING THE NEW GITOPS ZTP APPLICATIONS 36
- 3.7. ROLLING OUT THE GITOPS ZTP CONFIGURATION CHANGES 38

CHAPTER 4. INSTALLING MANAGED CLUSTERS WITH RHACM AND SITECONFIG RESOURCES **39**
- 4.1. GITOPS ZTP AND TOPOLOGY AWARE LIFECYCLE MANAGER 39
- 4.2. OVERVIEW OF DEPLOYING MANAGED CLUSTERS WITH GITOPS ZTP 41
  - Overview of the managed site installation process 41
- 4.3. CREATING THE MANAGED BARE-METAL HOST SECRETS 42
- 4.4. CONFIGURING DISCOVERY ISO KERNEL ARGUMENTS FOR INSTALLATIONS USING GITOPS ZTP 43
- 4.5. DEPLOYING A MANAGED CLUSTER WITH SITECONFIG AND GITOPS ZTP 45
  - 4.5.1. Accelerated provisioning of GitOps ZTP 50
    - 4.5.1.1. Activating accelerated ZTP 51
    - 4.5.1.2. The accelerated ZTP process 52
  - 4.5.2. Configuring IPsec encryption for single-node OpenShift clusters using GitOps ZTP and SiteConfig resources 52
  - 4.5.3. Single-node OpenShift SiteConfig CR installation reference 56
- 4.6. MONITORING MANAGED CLUSTER INSTALLATION PROGRESS 59
- 4.7. TROUBLESHOOTING GITOPS ZTP BY VALIDATING THE INSTALLATION CRS 59
- 4.8. TROUBLESHOOTING GITOPS ZTP VIRTUAL MEDIA BOOTING ON SUPERMICRO SERVERS 60
- 4.9. REMOVING A MANAGED CLUSTER SITE FROM THE GITOPS ZTP PIPELINE 61
- 4.10. REMOVING OBSOLETE CONTENT FROM THE GITOPS ZTP PIPELINE 61
- 4.11. TEARING DOWN THE GITOPS ZTP PIPELINE 62

CHAPTER 5. MANUALLY INSTALLING A SINGLE-NODE OPENSHIFT CLUSTER WITH GITOPS ZTP **63**
- 5.1. GENERATING GITOPS ZTP INSTALLATION AND CONFIGURATION CRS MANUALLY 63
- 5.2. CREATING THE MANAGED BARE-METAL HOST SECRETS 69
- 5.3. CONFIGURING DISCOVERY ISO KERNEL ARGUMENTS FOR MANUAL INSTALLATIONS USING GITOPS

ZTP 70
5.4. INSTALLING A SINGLE MANAGED CLUSTER 72
5.5. MONITORING THE MANAGED CLUSTER INSTALLATION STATUS 73
5.6. TROUBLESHOOTING THE MANAGED CLUSTER 74
5.7. RHACM GENERATED CLUSTER INSTALLATION CRS REFERENCE 75

CHAPTER 6. RECOMMENDED SINGLE-NODE OPENSHIFT CLUSTER CONFIGURATION FOR VDU APPLICATION WORKLOADS 77
6.1. RUNNING LOW LATENCY APPLICATIONS ON OPENSHIFT CONTAINER PLATFORM 77
6.2. RECOMMENDED CLUSTER HOST REQUIREMENTS FOR VDU APPLICATION WORKLOADS 77
6.3. CONFIGURING HOST FIRMWARE FOR LOW LATENCY AND HIGH PERFORMANCE 78
6.4. CONNECTIVITY PREREQUISITES FOR MANAGED CLUSTER NETWORKS 79
6.5. WORKLOAD PARTITIONING IN SINGLE-NODE OPENSHIFT WITH GITOPS ZTP 80
6.6. RECOMMENDED CLUSTER INSTALL MANIFESTS 80
6.6.1. Workload partitioning 81
6.6.2. Reduced platform management footprint 82
6.6.3. SCTP 84
6.6.4. Setting rcu_normal 85
6.6.5. Automatic kernel crash dumps with kdump 87
6.6.6. Disable automatic CRI-O cache wipe 89
6.6.7. Configuring crun as the default container runtime 90
6.7. RECOMMENDED POSTINSTALLATION CLUSTER CONFIGURATIONS 91
6.7.1. Operators 91
6.7.2. Operator subscriptions 94
6.7.3. Cluster logging and log forwarding 96
6.7.4. Performance profile 97
6.7.5. Configuring cluster time synchronization 99
6.7.6. PTP 100
6.7.7. Extended Tuned profile 109
6.7.8. SR-IOV 110
6.7.9. Console Operator 113
6.7.10. Alertmanager 113
6.7.11. Operator Lifecycle Manager 114
6.7.12. LVM Storage 114
6.7.13. Network diagnostics 115

CHAPTER 7. VALIDATING SINGLE-NODE OPENSHIFT CLUSTER TUNING FOR VDU APPLICATION WORKLOADS 116
7.1. RECOMMENDED FIRMWARE CONFIGURATION FOR VDU CLUSTER HOSTS 116
7.2. RECOMMENDED CLUSTER CONFIGURATIONS TO RUN VDU APPLICATIONS 118
7.2.1. Recommended cluster MachineConfig CRs for single-node OpenShift clusters 118
7.2.2. Recommended cluster Operators 119
7.2.3. Recommended cluster kernel configuration 119
7.2.4. Checking the realtime kernel version 121
7.3. CHECKING THAT THE RECOMMENDED CLUSTER CONFIGURATIONS ARE APPLIED 122

CHAPTER 8. ADVANCED MANAGED CLUSTER CONFIGURATION WITH SITECONFIG RESOURCES . . . 132
8.1. CUSTOMIZING EXTRA INSTALLATION MANIFESTS IN THE GITOPS ZTP PIPELINE 132
8.2. FILTERING CUSTOM RESOURCES USING SITECONFIG FILTERS 133
8.3. DELETING A NODE BY USING THE SITECONFIG CR 135

CHAPTER 9. MANAGING CLUSTER POLICES WITH POLICYGENERATOR RESOURCES 137
9.1. CONFIGURING MANAGED CLUSTER POLICIES BY USING POLICYGENERATOR RESOURCES 137
9.1.1. Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching 137

9.1.2. About the PolicyGenerator CRD 138
9.1.3. Recommendations when customizing PolicyGenerator CRs 144
9.1.4. PolicyGenerator CRs for RAN deployments 144
9.1.5. Customizing a managed cluster with PolicyGenerator CRs 146
9.1.6. Monitoring managed cluster policy deployment progress 147
9.1.7. Validating the generation of configuration policy CRs 149
9.1.8. Restarting policy reconciliation 151
9.1.9. Changing applied managed cluster CRs using policies 152
9.1.10. Indication of done for GitOps ZTP installations 154
9.2. ADVANCED MANAGED CLUSTER CONFIGURATION WITH POLICYGENERATOR RESOURCES 154
9.2.1. Deploying additional changes to clusters 155
9.2.2. Using PolicyGenerator CRs to override source CRs content 155
9.2.3. Adding custom content to the GitOps ZTP pipeline 158
9.2.4. Configuring policy compliance evaluation timeouts for PolicyGenerator CRs 161
9.2.5. Signalling GitOps ZTP cluster deployment completion with validator inform policies 163
9.2.6. Configuring power states using PolicyGenerator CRs 164
9.2.6.1. Configuring performance mode using PolicyGenerator CRs 165
9.2.6.2. Configuring high-performance mode using PolicyGenerator CRs 165
9.2.6.3. Configuring power saving mode using PolicyGenerator CRs 166
9.2.6.4. Maximizing power savings 167
9.2.7. Configuring LVM Storage using PolicyGenerator CRs 168
9.2.8. Configuring PTP events with PolicyGenerator CRs 169
9.2.8.1. Configuring PTP events that use HTTP transport 170
9.2.8.2. Configuring PTP events that use AMQP transport 173
9.2.9. Configuring bare-metal events with PolicyGenerator CRs 178
9.2.9.1. Configuring bare-metal events that use HTTP transport 178
9.2.9.2. Configuring bare-metal events that use AMQP transport 179
9.2.10. Configuring the Image Registry Operator for local caching of images 180
9.2.10.1. Configuring disk partitioning with SiteConfig 181
9.2.10.2. Configuring the image registry using PolicyGenerator CRs 184
9.3. UPDATING MANAGED CLUSTERS IN A DISCONNECTED ENVIRONMENT WITH POLICYGENERATOR RESOURCES AND TALM 188
9.3.1. Setting up the disconnected environment 188
9.3.2. Performing a platform update with PolicyGenerator CRs 190
9.3.3. Performing an Operator update with PolicyGenerator CRs 193
9.3.4. Troubleshooting missed Operator updates with PolicyGenerator CRs 199
9.3.5. Performing a platform and an Operator update together 200
9.3.6. Removing Performance Addon Operator subscriptions from deployed clusters with PolicyGenerator CRs 203
9.3.7. Pre-caching user-specified images with TALM on single-node OpenShift clusters 204
9.3.7.1. Creating the custom resources for pre-caching 206
9.3.8. About the auto-created ClusterGroupUpgrade CR for GitOps ZTP 209

CHAPTER 10. MANAGING CLUSTER POLICES WITH POLICYGENTEMPLATE RESOURCES 211
10.1. CONFIGURING MANAGED CLUSTER POLICIES BY USING POLICYGENTEMPLATE RESOURCES 211
10.1.1. About the PolicyGenTemplate CRD 211
10.1.2. Recommendations when customizing PolicyGenTemplate CRs 214
10.1.3. PolicyGenTemplate CRs for RAN deployments 215
10.1.4. Customizing a managed cluster with PolicyGenTemplate CRs 216
10.1.5. Monitoring managed cluster policy deployment progress 218
10.1.6. Validating the generation of configuration policy CRs 219
10.1.7. Restarting policy reconciliation 221
10.1.8. Changing applied managed cluster CRs using policies 222

10.1.9. Indication of done for GitOps ZTP installations 224
10.2. ADVANCED MANAGED CLUSTER CONFIGURATION WITH POLICYGENTEMPLATE RESOURCES 225
10.2.1. Deploying additional changes to clusters 225
10.2.2. Using PolicyGenTemplate CRs to override source CRs content 225
10.2.3. Adding custom content to the GitOps ZTP pipeline 228
10.2.4. Configuring policy compliance evaluation timeouts for PolicyGenTemplate CRs 231
10.2.5. Signalling GitOps ZTP cluster deployment completion with validator inform policies 232
10.2.6. Configuring power states using PolicyGenTemplate CRs 233
10.2.6.1. Configuring performance mode using PolicyGenTemplate CRs 234
10.2.6.2. Configuring high-performance mode using PolicyGenTemplate CRs 235
10.2.6.3. Configuring power saving mode using PolicyGenTemplate CRs 235
10.2.6.4. Maximizing power savings 237
10.2.7. Configuring LVM Storage using PolicyGenTemplate CRs 238
10.2.8. Configuring PTP events with PolicyGenTemplate CRs 239
10.2.8.1. Configuring PTP events that use HTTP transport 240
10.2.8.2. Configuring PTP events that use AMQP transport 241
10.2.9. Configuring bare-metal events with PolicyGenTemplate CRs 243
10.2.9.1. Configuring bare-metal events that use HTTP transport 243
10.2.9.2. Configuring bare-metal events that use AMQP transport 245
10.2.10. Configuring the Image Registry Operator for local caching of images 246
10.2.10.1. Configuring disk partitioning with SiteConfig 247
10.2.10.2. Configuring the image registry using PolicyGenTemplate CRs 250
10.3. UPDATING MANAGED CLUSTERS IN A DISCONNECTED ENVIRONMENT WITH POLICYGENTEMPLATE RESOURCES AND TALM 253
10.3.1. Setting up the disconnected environment 254
10.3.2. Performing a platform update with PolicyGenTemplate CRs 256
10.3.3. Performing an Operator update with PolicyGenTemplate CRs 259
10.3.4. Troubleshooting missed Operator updates with PolicyGenTemplate CRs 264
10.3.5. Performing a platform and an Operator update together 265
10.3.6. Removing Performance Addon Operator subscriptions from deployed clusters with PolicyGenTemplate CRs 267
10.3.7. Pre-caching user-specified images with TALM on single-node OpenShift clusters 269
10.3.7.1. Creating the custom resources for pre-caching 270
10.3.8. About the auto-created ClusterGroupUpgrade CR for GitOps ZTP 274

CHAPTER 11. USING HUB TEMPLATES IN POLICYGENERATOR OR POLICYGENTEMPLATE CRS 276
11.1. USING RHACM HUB CLUSTER TEMPLATES IN CONFIGURATION POLICIES 276
11.2. EXAMPLE HUB TEMPLATES 277
11.3. SPECIFYING GROUP AND SITE CONFIGURATIONS IN GROUP POLICYGENERATOR OR POLICYGENTEMPLATE CRS 277
11.4. SYNCING NEW CONFIGMAP CHANGES TO EXISTING POLICYGENERATOR OR POLICYGENTEMPLATE CRS 284

CHAPTER 12. UPDATING MANAGED CLUSTERS WITH THE TOPOLOGY AWARE LIFECYCLE MANAGER 286
12.1. ABOUT THE TOPOLOGY AWARE LIFECYCLE MANAGER CONFIGURATION 286
12.2. ABOUT MANAGED POLICIES USED WITH TOPOLOGY AWARE LIFECYCLE MANAGER 286
12.3. INSTALLING THE TOPOLOGY AWARE LIFECYCLE MANAGER BY USING THE WEB CONSOLE 287
12.4. INSTALLING THE TOPOLOGY AWARE LIFECYCLE MANAGER BY USING THE CLI 288
12.5. ABOUT THE CLUSTERGROUPUPGRADE CR 289
12.5.1. Selecting clusters 290
12.5.2. Validating 292
12.5.3. Pre-caching 293
12.5.4. Creating a backup 293

12.5.5. Updating clusters 293
12.5.6. Update status 296
12.5.7. Blocking ClusterGroupUpgrade CRs 298
12.6. UPDATE POLICIES ON MANAGED CLUSTERS 305
12.6.1. Configuring Operator subscriptions for managed clusters that you install with TALM 306
12.6.2. Applying update policies to managed clusters 307
12.7. CREATING A BACKUP OF CLUSTER RESOURCES BEFORE UPGRADE 314
12.7.1. Creating a ClusterGroupUpgrade CR with backup 314
12.7.2. Recovering a cluster after a failed upgrade 317
12.8. USING THE CONTAINER IMAGE PRE-CACHE FEATURE 319
12.8.1. Using the container image pre-cache filter 320
12.8.2. Creating a ClusterGroupUpgrade CR with pre-caching 321
12.9. TROUBLESHOOTING THE TOPOLOGY AWARE LIFECYCLE MANAGER 323
12.9.1. General troubleshooting 324
12.9.2. Cannot modify the ClusterUpgradeGroup CR 324
12.9.3. Managed policies 325
Checking managed policies on the system 325
Checking remediationAction mode 325
Checking policy compliance state 326
12.9.4. Clusters 326
Checking if managed clusters are present 326
Checking if managed clusters are available 327
Checking clusterLabelSelector 327
Checking if canary clusters are present 328
Checking the pre-caching status on spoke clusters 329
12.9.5. Remediation Strategy 329
Checking if remediationStrategy is present in the ClusterGroupUpgrade CR 329
Checking if maxConcurrency is specified in the ClusterGroupUpgrade CR 329
12.9.6. Topology Aware Lifecycle Manager 329
Checking condition message and status in the ClusterGroupUpgrade CR 329
Checking if status.remediationPlan was computed 330
Errors in the TALM manager container 330
Clusters are not compliant to some policies after a ClusterGroupUpgrade CR has completed 330
Auto-created ClusterGroupUpgrade CR in the GitOps ZTP workflow has no managed policies 331
Pre-caching has failed 331

CHAPTER 13. EXPANDING SINGLE-NODE OPENSHIFT CLUSTERS WITH GITOPS ZTP 333
13.1. APPLYING PROFILES TO THE WORKER NODE WITH POLICYGENERATOR OR POLICYGENTEMPLATE RESOURCES 333
13.2. ENSURING PTP AND SR-IOV DAEMON SELECTOR COMPATIBILITY 334
13.3. PTP AND SR-IOV NODE SELECTOR COMPATIBILITY 335
13.4. USING POLICYGENERATOR CRS TO APPLY WORKER NODE POLICIES TO WORKER NODES 335
13.5. USING POLICYGENTEMPLATE CRS TO APPLY WORKER NODE POLICIES TO WORKER NODES 338
13.6. ADDING WORKER NODES TO SINGLE-NODE OPENSHIFT CLUSTERS WITH GITOPS ZTP 341

CHAPTER 14. PRE-CACHING IMAGES FOR SINGLE-NODE OPENSHIFT DEPLOYMENTS 344
14.1. GETTING THE FACTORY-PRECACHING-CLI TOOL 344
14.2. BOOTING FROM A LIVE OPERATING SYSTEM IMAGE 345
14.3. PARTITIONING THE DISK 346
14.3.1. Creating the partition 347
14.3.2. Mounting the partition 349
14.4. DOWNLOADING THE IMAGES 349
14.4.1. Downloading with parallel workers 350

14.4.2. Preparing to download the OpenShift Container Platform images 350
14.4.3. Downloading the OpenShift Container Platform images 351
14.4.4. Downloading the Operator images 354
14.4.5. Pre-caching custom images in disconnected environments 355
14.5. PRE-CACHING IMAGES IN GITOPS ZTP 358
14.5.1. Understanding the clusters.ignitionConfigOverride field 363
14.5.2. Understanding the nodes.installerArgs field 363
14.5.3. Understanding the nodes.ignitionConfigOverride field 364
14.6. TROUBLESHOOTING A "RENDERED CATALOG IS INVALID" ERROR 364

CHAPTER 15. IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS 366
15.1. UNDERSTANDING THE IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS 366
15.1.1. Stages of the image-based upgrade 367
15.1.1.1. Idle stage 368
15.1.1.2. Prep stage 369
15.1.1.3. Upgrade stage 370
15.1.1.4. (Optional) Rollback stage 371
15.1.2. Guidelines for the image-based upgrade 372
15.1.2.1. Minimum software version of components 372
15.1.2.2. Hub cluster guidelines 373
15.1.2.3. Seed image guidelines 373
15.1.2.4. OADP backup and restore guidelines 374
15.1.2.4.1. lca.openshift.io/apply-wave guidelines 375
15.1.2.4.2. lca.openshift.io/apply-label guidelines 375
15.1.2.5. Extra manifest guidelines 376
15.2. PREPARING FOR AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS 377
15.2.1. Configuring a shared container directory for the image-based upgrade 377
15.2.1.1. Configuring a shared container directory between ostree stateroots 377
15.2.1.2. Configuring a shared container directory between ostree stateroots when using GitOps ZTP 378
15.2.2. Installing Operators for the image-based upgrade 381
15.2.2.1. Installing the Lifecycle Agent by using the CLI 381
15.2.2.2. Installing the Lifecycle Agent by using the web console 383
15.2.2.3. Installing the Lifecycle Agent with GitOps ZTP 383
15.2.2.4. Installing and configuring the OADP Operator with GitOps ZTP 385
15.2.3. Generating a seed image for the image-based upgrade with Lifecycle Agent 390
15.2.3.1. Seed image configuration 390
15.2.3.1.1. Seed image configuration using the RAN DU profile 391
15.2.3.2. Generating a seed image with the Lifecycle Agent 392
15.2.4. Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent 395
15.2.4.1. Creating OADP ConfigMap objects for the image-based upgrade with Lifecycle Agent 395
15.2.4.2. Creating ConfigMap objects of extra manifests for the image-based upgrade with Lifecycle Agent 400
15.2.4.3. Creating ConfigMap objects of custom catalog sources for the image-based upgrade with Lifecycle Agent 401
15.2.5. Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent using GitOps ZTP 402
15.2.5.1. Creating OADP resources for the image-based upgrade with GitOps ZTP 402
15.2.5.2. Labeling extra manifests for the image-based upgrade with GitOps ZTP 409
15.3. PERFORMING AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS 411
15.3.1. Moving to the Prep stage of the image-based upgrade with Lifecycle Agent 411
15.3.2. Moving to the Upgrade stage of the image-based upgrade with Lifecycle Agent 413
15.3.3. (Optional) Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent 416
15.3.4. Troubleshooting image-based upgrades with Lifecycle Agent 417
15.3.4.1. Collecting logs 417

15.3.4.2. AbortFailed or FinalizeFailed error 418
15.3.4.2.1. Cleaning up stateroot manually 418
15.3.4.2.2. Cleaning up OADP resources manually 419
15.3.4.3. LVM Storage volume contents not restored 419
15.3.4.3.1. Missing LVM Storage-related fields in Backup CR 419
15.3.4.3.2. Missing LVM Storage-related fields in Restore CR 420
15.3.4.4. Debugging failed Backup and Restore CRs 422
15.4. PERFORMING AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS USING GITOPS ZTP 422
15.4.1. Moving to the Prep stage of the image-based upgrade with Lifecycle Agent and GitOps ZTP 423
15.4.2. Moving to the Upgrade stage of the image-based upgrade with Lifecycle Agent and GitOps ZTP 426
15.4.3. (Optional) Moving to the Rollback stage with Lifecycle Agent and GitOps ZTP 428
15.4.4. Troubleshooting image-based upgrades with Lifecycle Agent 430
15.4.4.1. Collecting logs 430
15.4.4.2. AbortFailed or FinalizeFailed error 431
15.4.4.2.1. Cleaning up stateroot manually 431
15.4.4.2.2. Cleaning up OADP resources manually 432
15.4.4.3. LVM Storage volume contents not restored 432
15.4.4.3.1. Missing LVM Storage-related fields in Backup CR 432
15.4.4.3.2. Missing LVM Storage-related fields in Restore CR 433
15.4.4.4. Debugging failed Backup and Restore CRs 435

CHAPTER 1. CHALLENGES OF THE NETWORK FAR EDGE

Edge computing presents complex challenges when managing many sites in geographically displaced locations. Use GitOps Zero Touch Provisioning (ZTP) to provision and manage sites at the far edge of the network.

1.1. OVERCOMING THE CHALLENGES OF THE NETWORK FAR EDGE

Today, service providers want to deploy their infrastructure at the edge of the network. This presents significant challenges:

- How do you handle deployments of many edge sites in parallel?
- What happens when you need to deploy sites in disconnected environments?
- How do you manage the lifecycle of large fleets of clusters?

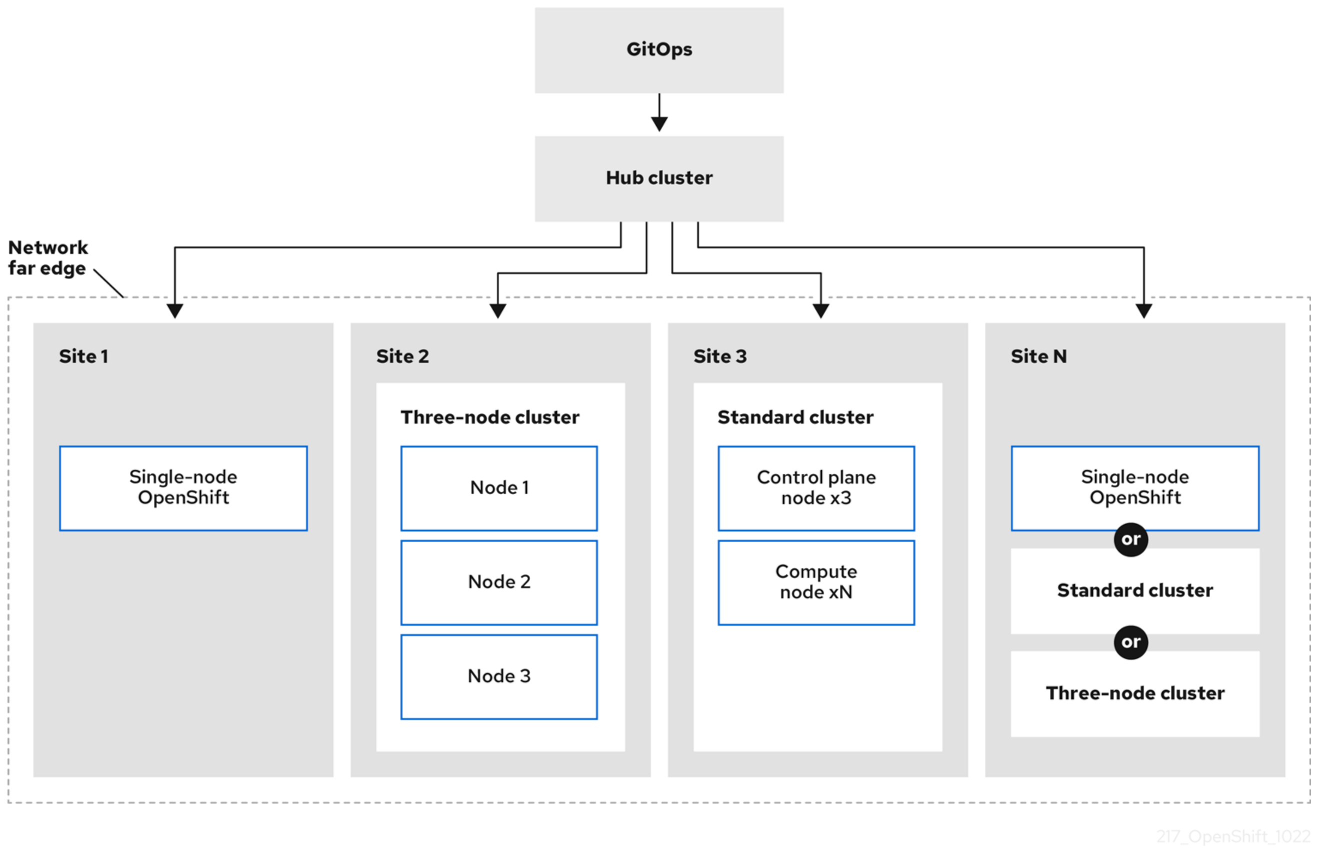
GitOps Zero Touch Provisioning (ZTP) and *GitOps* meets these challenges by allowing you to provision remote edge sites at scale with declarative site definitions and configurations for bare-metal equipment. Template or overlay configurations install OpenShift Container Platform features that are required for CNF workloads. The full lifecycle of installation and upgrades is handled through the GitOps ZTP pipeline.

GitOps ZTP uses GitOps for infrastructure deployments. With GitOps, you use declarative YAML files and other defined patterns stored in Git repositories. Red Hat Advanced Cluster Management (RHACM) uses your Git repositories to drive the deployment of your infrastructure.

GitOps provides traceability, role-based access control (RBAC), and a single source of truth for the desired state of each site. Scalability issues are addressed by Git methodologies and event driven operations through webhooks.

You start the GitOps ZTP workflow by creating declarative site definition and configuration custom resources (CRs) that the GitOps ZTP pipeline delivers to the edge nodes.

The following diagram shows how GitOps ZTP works within the far edge framework.



1.2. USING GITOPS ZTP TO PROVISION CLUSTERS AT THE NETWORK FAR EDGE

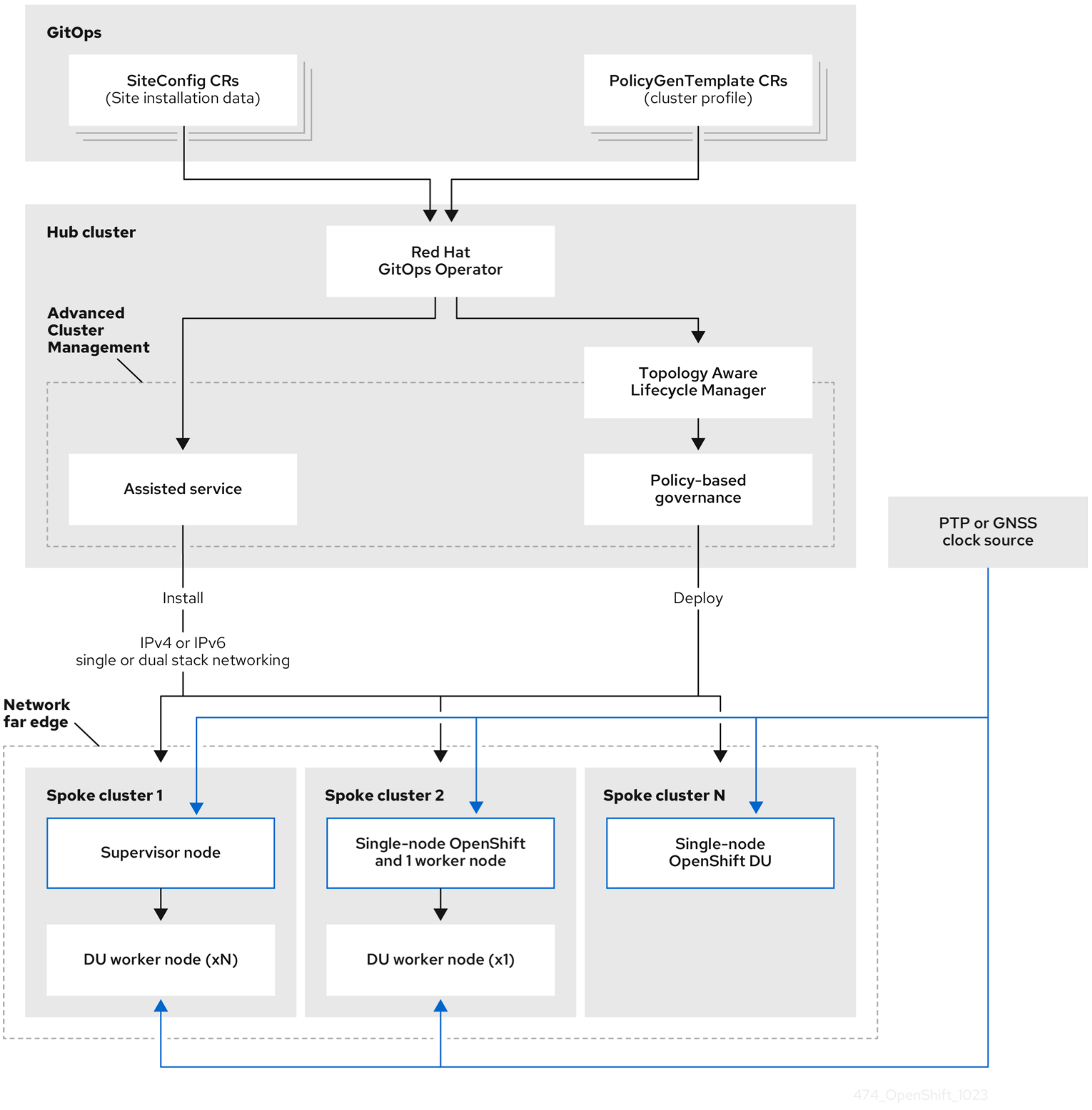
Red Hat Advanced Cluster Management (RHACM) manages clusters in a hub-and-spoke architecture, where a single hub cluster manages many spoke clusters. Hub clusters running RHACM provision and deploy the managed clusters by using GitOps Zero Touch Provisioning (ZTP) and the assisted service that is deployed when you install RHACM.

The assisted service handles provisioning of OpenShift Container Platform on single node clusters, three-node clusters, or standard clusters running on bare metal.

A high-level overview of using GitOps ZTP to provision and maintain bare-metal hosts with OpenShift Container Platform is as follows:

- A hub cluster running RHACM manages an OpenShift image registry that mirrors the OpenShift Container Platform release images. RHACM uses the OpenShift image registry to provision the managed clusters.
- You manage the bare-metal hosts in a YAML format inventory file, versioned in a Git repository.
- You make the hosts ready for provisioning as managed clusters, and use RHACM and the assisted service to install the bare-metal hosts on site.

Installing and deploying the clusters is a two-stage process, involving an initial installation phase, and a subsequent configuration and deployment phase. The following diagram illustrates this workflow:



1.3. INSTALLING MANAGED CLUSTERS WITH SITECONFIG RESOURCES AND RHACM

GitOps Zero Touch Provisioning (ZTP) uses **SiteConfig** custom resources (CRs) in a Git repository to manage the processes that install OpenShift Container Platform clusters. The **SiteConfig** CR contains cluster-specific parameters required for installation. It has options for applying select configuration CRs during installation including user defined extra manifests.

The GitOps ZTP plugin processes **SiteConfig** CRs to generate a collection of CRs on the hub cluster. This triggers the assisted service in Red Hat Advanced Cluster Management (RHACM) to install OpenShift Container Platform on the bare-metal host. You can find installation status and error messages in these CRs on the hub cluster.

You can provision single clusters manually or in batches with GitOps ZTP:

Provisioning a single cluster

Create a single **SiteConfig** CR and related installation and configuration CRs for the cluster, and apply them in the hub cluster to begin cluster provisioning. This is a good way to test your CRs before deploying on a larger scale.

Provisioning many clusters

Install managed clusters in batches of up to 400 by defining **SiteConfig** and related CRs in a Git repository. ArgoCD uses the **SiteConfig** CRs to deploy the sites. The RHACM policy generator creates the manifests and applies them to the hub cluster. This starts the cluster provisioning process.

1.4. CONFIGURING MANAGED CLUSTERS WITH POLICIES AND POLICYGENTEMPLATE RESOURCES

GitOps Zero Touch Provisioning (ZTP) uses Red Hat Advanced Cluster Management (RHACM) to configure clusters by using a policy-based governance approach to applying the configuration.

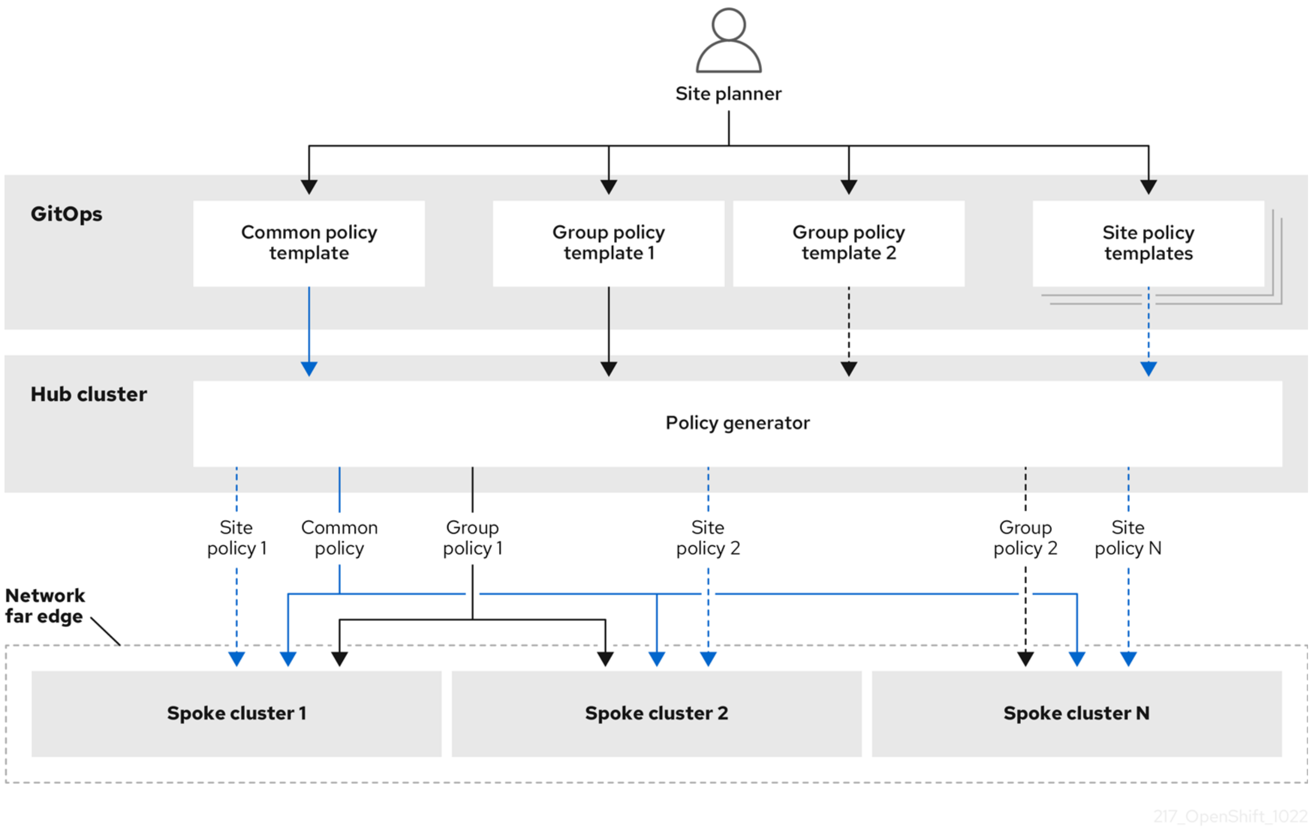
The policy generator or **PolicyGen** is a plugin for the GitOps Operator that enables the creation of RHACM policies from a concise template. The tool can combine multiple CRs into a single policy, and you can generate multiple policies that apply to various subsets of clusters in your fleet.

NOTE

For scalability and to reduce the complexity of managing configurations across the fleet of clusters, use configuration CRs with as much commonality as possible.

- Where possible, apply configuration CRs using a fleet-wide common policy.
- The next preference is to create logical groupings of clusters to manage as much of the remaining configurations as possible under a group policy.
- When a configuration is unique to an individual site, use RHACM templating on the hub cluster to inject the site-specific data into a common or group policy. Alternatively, apply an individual site policy for the site.

The following diagram shows how the policy generator interacts with GitOps and RHACM in the configuration phase of cluster deployment.



For large fleets of clusters, it is typical for there to be a high-level of consistency in the configuration of those clusters.

The following recommended structuring of policies combines configuration CRs to meet several goals:

- Describe common configurations once and apply to the fleet.
- Minimize the number of maintained and managed policies.
- Support flexibility in common configurations for cluster variants.

Table 1.1. Recommended PolicyGenTemplate policy categories

Policy category	Description
Common	A policy that exists in the common category is applied to all clusters in the fleet. Use common **PolicyGenerator** CRs to apply common installation settings across all cluster types.
Groups	A policy that exists in the groups category is applied to a group of clusters in the fleet. Use group **PolicyGenerator** CRs to manage specific aspects of single-node, three-node, and standard cluster installations. Cluster groups can also follow geographic region, hardware variant, etc.
Sites	A policy that exists in the sites category is applied to a specific cluster site. Any cluster can have its own specific policies maintained.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching
- Preparing the GitOps ZTP Git repository

CHAPTER 2. PREPARING THE HUB CLUSTER FOR GITOPS ZTP

To use RHACM in a disconnected environment, create a mirror registry that mirrors the OpenShift Container Platform release images and Operator Lifecycle Manager (OLM) catalog that contains the required Operator images. OLM manages, installs, and upgrades Operators and their dependencies in the cluster. You can also use a disconnected mirror host to serve the RHCOS ISO and RootFS disk images that are used to provision the bare-metal hosts.

2.1. TELCO RAN DU 4.16 VALIDATED SOFTWARE COMPONENTS

The Red Hat telco RAN DU 4.16 solution has been validated using the following Red Hat software products for OpenShift Container Platform managed clusters and hub clusters.

Table 2.1. Telco RAN DU managed cluster validated software components

Component	Software version
Managed cluster version	4.16
Cluster Logging Operator	5.9
Local Storage Operator	4.16
PTP Operator	4.16
SRIOV Operator	4.16
Node Tuning Operator	4.16
Logging Operator	4.16
SRIOV-FEC Operator	2.9

Table 2.2. Hub cluster validated software components

Component	Software version
Hub cluster version	4.16
GitOps ZTP plugin	4.16
Red Hat Advanced Cluster Management (RHACM)	2.11
Red Hat OpenShift GitOps	1.12
Topology Aware Lifecycle Manager (TALM)	4.16

2.2. RECOMMENDED HUB CLUSTER SPECIFICATIONS AND MANAGED CLUSTER LIMITS FOR GITOPS ZTP

With GitOps Zero Touch Provisioning (ZTP), you can manage thousands of clusters in geographically dispersed regions and networks. The Red Hat Performance and Scale lab successfully created and managed 3500 virtual single-node OpenShift clusters with a reduced DU profile from a single Red Hat Advanced Cluster Management (RHACM) hub cluster in a lab environment.

In real-world situations, the scaling limits for the number of clusters that you can manage will vary depending on various factors affecting the hub cluster. For example:

Hub cluster resources

Available hub cluster host resources (CPU, memory, storage) are an important factor in determining how many clusters the hub cluster can manage. The more resources allocated to the hub cluster, the more managed clusters it can accommodate.

Hub cluster storage

The hub cluster host storage IOPS rating and whether the hub cluster hosts use NVMe storage can affect hub cluster performance and the number of clusters it can manage.

Network bandwidth and latency

Slow or high-latency network connections between the hub cluster and managed clusters can impact how the hub cluster manages multiple clusters.

Managed cluster size and complexity

The size and complexity of the managed clusters also affects the capacity of the hub cluster. Larger managed clusters with more nodes, namespaces, and resources require additional processing and management resources. Similarly, clusters with complex configurations such as the RAN DU profile or diverse workloads can require more resources from the hub cluster.

Number of managed policies

The number of policies managed by the hub cluster scaled over the number of managed clusters bound to those policies is an important factor that determines how many clusters can be managed.

Monitoring and management workloads

RHACM continuously monitors and manages the managed clusters. The number and complexity of monitoring and management workloads running on the hub cluster can affect its capacity. Intensive monitoring or frequent reconciliation operations can require additional resources, potentially limiting the number of manageable clusters.

RHACM version and configuration

Different versions of RHACM can have varying performance characteristics and resource requirements. Additionally, the configuration settings of RHACM, such as the number of concurrent reconciliations or the frequency of health checks, can affect the managed cluster capacity of the hub cluster.

Use the following representative configuration and network specifications to develop your own Hub cluster and network specifications.

IMPORTANT

The following guidelines are based on internal lab benchmark testing only and do not represent complete bare-metal host specifications.

Table 2.3. Representative three-node hub cluster machine specifications

Requirement	Description
OpenShift Container Platform	version 4.13
RHACM	version 2.7
Topology Aware Lifecycle Manager (TALM)	version 4.13
Server hardware	3 x Dell PowerEdge R650 rack servers
NVMe hard disks	• 50 GB disk for **/var/lib/etcd** • 2.9 TB disk for **/var/lib/containers**
SSD hard disks	• 1 SSD split into 15 200GB thin-provisioned logical volumes provisioned as **PV** CRs • 1 SSD serving as an extra large **PV** resource
Number of applied DU profile policies	5

IMPORTANT

The following network specifications are representative of a typical real-world RAN network and were applied to the scale lab environment during testing.

Table 2.4. Simulated lab environment network specifications

Specification	Description
Round-trip time (RTT) latency	50 ms
Packet loss	0.02% packet loss
Network bandwidth limit	20 Mbps

Additional resources

- Creating and managing single-node OpenShift clusters with RHACM

2.3. INSTALLING GITOPS ZTP IN A DISCONNECTED ENVIRONMENT

Use Red Hat Advanced Cluster Management (RHACM), Red Hat OpenShift GitOps, and Topology Aware Lifecycle Manager (TALM) on the hub cluster in the disconnected environment to manage the deployment of multiple managed clusters.

Prerequisites

- You have installed the OpenShift Container Platform CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have configured a disconnected mirror registry for use in the cluster.

> **NOTE**
>
> The disconnected mirror registry that you create must contain a version of TALM backup and pre-cache images that matches the version of TALM running in the hub cluster. The spoke cluster must be able to resolve these images in the disconnected mirror registry.

Procedure

- Install RHACM in the hub cluster. See Installing RHACM in a disconnected environment .
- Install GitOps and TALM in the hub cluster.

Additional resources

- Installing OpenShift GitOps
- Installing TALM
- Mirroring an Operator catalog

2.4. ADDING RHCOS ISO AND ROOTFS IMAGES TO THE DISCONNECTED MIRROR HOST

Before you begin installing clusters in the disconnected environment with Red Hat Advanced Cluster Management (RHACM), you must first host Red Hat Enterprise Linux CoreOS (RHCOS) images for it to use. Use a disconnected mirror to host the RHCOS images.

Prerequisites

- Deploy and configure an HTTP server to host the RHCOS image resources on the network. You must be able to access the HTTP server from your computer, and from the machines that you create.

> **IMPORTANT**
>
> The RHCOS images might not change with every release of OpenShift Container Platform. You must download images with the highest version that is less than or equal to the version that you install. Use the image versions that match your OpenShift Container Platform version if they are available. You require ISO and RootFS images to install RHCOS on the hosts. RHCOS QCOW2 images are not supported for this installation type.

Procedure

1. Log in to the mirror host.

2. Obtain the RHCOS ISO and RootFS images from mirror.openshift.com, for example:

   a. Export the required image names and OpenShift Container Platform version as environment variables:

   ```
   $ export ISO_IMAGE_NAME=<iso_image_name> 1
   ```

   ```
   $ export ROOTFS_IMAGE_NAME=<rootfs_image_name> 1
   ```

   ```
   $ export OCP_VERSION=<ocp_version> 1
   ```

   1 ISO image name, for example, **rhcos-4.16.1-x86_64-live.x86_64.iso**

   1 RootFS image name, for example, **rhcos-4.16.1-x86_64-live-rootfs.x86_64.img**

   1 OpenShift Container Platform version, for example, **4.16.1**

   b. Download the required images:

   ```
   $ sudo wget https://mirror.openshift.com/pub/openshift-
   v4/dependencies/rhcos/4.16/${OCP_VERSION}/${ISO_IMAGE_NAME} -O
   /var/www/html/${ISO_IMAGE_NAME}
   ```

   ```
   $ sudo wget https://mirror.openshift.com/pub/openshift-
   v4/dependencies/rhcos/4.16/${OCP_VERSION}/${ROOTFS_IMAGE_NAME} -O
   /var/www/html/${ROOTFS_IMAGE_NAME}
   ```

Verification steps

- Verify that the images downloaded successfully and are being served on the disconnected mirror host, for example:

  ```
  $ wget http://$(hostname)/${ISO_IMAGE_NAME}
  ```

  Example output

  ```
  Saving to: rhcos-4.16.1-x86_64-live.x86_64.iso
  rhcos-4.16.1-x86_64-live.x86_64.iso-  11%[====>    ]  10.01M  4.71MB/s
  ```

Additional resources

- Creating a mirror registry
- Mirroring images for a disconnected installation

2.5. ENABLING THE ASSISTED SERVICE

Red Hat Advanced Cluster Management (RHACM) uses the assisted service to deploy OpenShift Container Platform clusters. The assisted service is deployed automatically when you enable the MultiClusterHub Operator on Red Hat Advanced Cluster Management (RHACM). After that, you need to configure the **Provisioning** resource to watch all namespaces and to update the **AgentServiceConfig** custom resource (CR) with references to the ISO and RootFS images that are hosted on the mirror registry HTTP server.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have RHACM with MultiClusterHub enabled.

Procedure

1. Enable the **Provisioning** resource to watch all namespaces and configure mirrors for disconnected environments. For more information, see Enabling the central infrastructure management service.
2. Update the **AgentServiceConfig** CR by running the following command:

   ```
   $ oc edit AgentServiceConfig
   ```

3. Add the following entry to the **items.spec.osImages** field in the CR:

   ```
   - cpuArchitecture: x86_64
       openshiftVersion: "4.16"
       rootFSUrl: https://<host>/<path>/rhcos-live-rootfs.x86_64.img
       url: https://<mirror-registry>/<path>/rhcos-live.x86_64.iso
   ```

   where:

   <host>
   : Is the fully qualified domain name (FQDN) for the target mirror registry HTTP server.

   <path>
   : Is the path to the image on the target mirror registry.

   Save and quit the editor to apply the changes.

2.6. CONFIGURING THE HUB CLUSTER TO USE A DISCONNECTED MIRROR REGISTRY

You can configure the hub cluster to use a disconnected mirror registry for a disconnected environment.

Prerequisites

- You have a disconnected hub cluster installation with Red Hat Advanced Cluster Management (RHACM) 2.10 installed.
- You have hosted the **rootfs** and **iso** images on an HTTP server. See the *Additional resources* section for guidance about *Mirroring the OpenShift Container Platform image repository* .

WARNING

If you enable TLS for the HTTP server, you must confirm the root certificate is signed by an authority trusted by the client and verify the trusted certificate chain between your OpenShift Container Platform hub and managed clusters and the HTTP server. Using a server configured with an untrusted certificate prevents the images from being downloaded to the image creation service. Using untrusted HTTPS servers is not supported.

Procedure

1. Create a **ConfigMap** containing the mirror registry config:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: assisted-installer-mirror-config
  namespace: multicluster-engine (1)
  labels:
    app: assisted-service
data:
  ca-bundle.crt: | (2)
    -----BEGIN CERTIFICATE-----
    <certificate_contents>
    -----END CERTIFICATE-----

  registries.conf: | (3)
    unqualified-search-registries = ["registry.access.redhat.com", "docker.io"]

    [[registry]]
      prefix = ""
      location = "quay.io/example-repository" (4)
      mirror-by-digest-only = true

      [[registry.mirror]]
      location = "mirror1.registry.corp.com:5000/example-repository" (5)
```

(1) The **ConfigMap** namespace must be set to **multicluster-engine**.

(2) The mirror registry's certificate that is used when creating the mirror registry.

(3) The configuration file for the mirror registry. The mirror registry configuration adds mirror information to the **/etc/containers/registries.conf** file in the discovery image. The mirror information is stored in the **imageContentSources** section of the **install-config.yaml** file when the information is passed to the installation program. The Assisted Service pod that runs on the hub cluster fetches the container images from the configured mirror registry.

(4) The URL of the mirror registry. You must use the URL from the **imageContentSources** section by running the **oc adm release mirror** command when you configure the mirror registry. For more information, see the *Mirroring the OpenShift Container Platform image repository* section.

5 The registries defined in the **registries.conf** file must be scoped by repository, not by registry. In this example, both the **quay.io/example-repository** and the

This updates **mirrorRegistryRef** in the **AgentServiceConfig** custom resource, as shown below:

Example output

```
apiVersion: agent-install.openshift.io/v1beta1
kind: AgentServiceConfig
metadata:
  name: agent
  namespace: multicluster-engine (1)
spec:
  databaseStorage:
    volumeName: <db_pv_name>
    accessModes:
    - ReadWriteOnce
    resources:
      requests:
        storage: <db_storage_size>
  filesystemStorage:
    volumeName: <fs_pv_name>
    accessModes:
    - ReadWriteOnce
    resources:
      requests:
        storage: <fs_storage_size>
  mirrorRegistryRef:
    name: assisted-installer-mirror-config (2)
  osImages:
    - openshiftVersion: <ocp_version>
      url: <iso_url> (3)
```

1 Set the **AgentServiceConfig** namespace to **multicluster-engine** to match the **ConfigMap** namespace

2 Set **mirrorRegistryRef.name** to match the definition specified in the related **ConfigMap** CR

3 Set the URL for the ISO hosted on the **httpd** server

IMPORTANT

A valid NTP server is required during cluster installation. Ensure that a suitable NTP server is available and can be reached from the installed clusters through the disconnected network.

Additional resources

- Mirroring the OpenShift Container Platform image repository

2.7. CONFIGURING THE HUB CLUSTER TO USE UNAUTHENTICATED REGISTRIES

You can configure the hub cluster to use unauthenticated registries. Unauthenticated registries does not require authentication to access and download images.

Prerequisites

- You have installed and configured a hub cluster and installed Red Hat Advanced Cluster Management (RHACM) on the hub cluster.
- You have installed the OpenShift Container Platform CLI (oc).
- You have logged in as a user with **cluster-admin** privileges.
- You have configured an unauthenticated registry for use with the hub cluster.

Procedure

1. Update the **AgentServiceConfig** custom resource (CR) by running the following command:

   ```
   $ oc edit AgentServiceConfig agent
   ```

2. Add the **unauthenticatedRegistries** field in the CR:

   ```
   apiVersion: agent-install.openshift.io/v1beta1
   kind: AgentServiceConfig
   metadata:
     name: agent
   spec:
     unauthenticatedRegistries:
     - example.registry.com
     - example.registry2.com
     ...
   ```

   Unauthenticated registries are listed under **spec.unauthenticatedRegistries** in the **AgentServiceConfig** resource. Any registry on this list is not required to have an entry in the pull secret used for the spoke cluster installation. **assisted-service** validates the pull secret by making sure it contains the authentication information for every image registry used for installation.

NOTE

Mirror registries are automatically added to the ignore list and do not need to be added under **spec.unauthenticatedRegistries**. Specifying the **PUBLIC_CONTAINER_REGISTRIES** environment variable in the **ConfigMap** overrides the default values with the specified value. The **PUBLIC_CONTAINER_REGISTRIES** defaults are quay.io and registry.svc.ci.openshift.org.

Verification

Verify that you can access the newly added registry from the hub cluster by running the following commands:

1. Open a debug shell prompt to the hub cluster:

```
$ oc debug node/<node_name>
```

2. Test access to the unauthenticated registry by running the following command:

```
sh-4.4# podman login -u kubeadmin -p $(oc whoami -t) <unauthenticated_registry>
```

where:

<unauthenticated_registry>
: Is the new registry, for example, **unauthenticated-image-registry.openshift-image-registry.svc:5000**.

Example output

```
Login Succeeded!
```

2.8. CONFIGURING THE HUB CLUSTER WITH ARGOCD

You can configure the hub cluster with a set of ArgoCD applications that generate the required installation and policy custom resources (CRs) for each site with GitOps Zero Touch Provisioning (ZTP).

NOTE

Red Hat Advanced Cluster Management (RHACM) uses **SiteConfig** CRs to generate the Day 1 managed cluster installation CRs for ArgoCD. Each ArgoCD application can manage a maximum of 300 **SiteConfig** CRs.

Prerequisites

- You have a OpenShift Container Platform hub cluster with Red Hat Advanced Cluster Management (RHACM) and Red Hat OpenShift GitOps installed.
- You have extracted the reference deployment from the GitOps ZTP plugin container as described in the "Preparing the GitOps ZTP site configuration repository" section. Extracting the reference deployment creates the **out/argocd/deployment** directory referenced in the following procedure.

Procedure

1. Prepare the ArgoCD pipeline configuration:
   a. Create a Git repository with the directory structure similar to the example directory. For more information, see "Preparing the GitOps ZTP site configuration repository".
   b. Configure access to the repository using the ArgoCD UI. Under **Settings** configure the following:
      - **Repositories** - Add the connection information. The URL must end in **.git**, for example, **https://repo.example.com/repo.git** and credentials.
      - **Certificates** - Add the public certificate for the repository, if needed.
   c. Modify the two ArgoCD applications, **out/argocd/deployment/clusters-app.yaml** and **out/argocd/deployment/policies-app.yaml**, based on your Git repository:

- Update the URL to point to the Git repository. The URL ends with **.git**, for example, **https://repo.example.com/repo.git**.
- The **targetRevision** indicates which Git repository branch to monitor.
- **path** specifies the path to the **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** CRs, respectively.

2. To install the GitOps ZTP plugin, patch the ArgoCD instance in the hub cluster with the relevant multicluster engine (MCE) subscription image. Customize the patch file that you previously extracted into the **out/argocd/deployment/** directory for your environment.

   a. Select the **multicluster-operators-subscription** image that matches your RHACM version.

Table 2.5. **multicluster-operators-subscription** image versions

OpenShift Container Platform version	RHACM version	MCE version	MCE RHEL version	MCE image
4.14, 4.15, 4.16	2.8, 2.9	2.8, 2.9	RHEL 8	**registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel8:v2.8** **registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel8:v2.9**
4.14, 4.15, 4.16	2.10	2.10	RHEL 9	**registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel9:v2.10**

IMPORTANT

The version of the **multicluster-operators-subscription** image should match the RHACM version. Beginning with the MCE 2.10 release, RHEL 9 is the base image for **multicluster-operators-subscription** images.

   b. Add the following configuration to the **out/argocd/deployment/argocd-openshift-gitops-patch.json** file:

```
{
  "args": [
    "-c",
    "mkdir -p /.config/kustomize/plugin/policy.open-cluster-management.io/v1/policygenerator && cp /policy-generator/PolicyGenerator-not-fips-compliant /.config/kustomize/plugin/policy.open-cluster-management.io/v1/policygenerator/PolicyGenerator" (1)
  ],
  "command": [
    "/bin/bash"
  ],
    "image": "registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel9:v2.10", (2)
(3)
    "name": "policy-generator-install",
    "imagePullPolicy": "Always",
    "volumeMounts": [
      {
        "mountPath": "/.config",
        "name": "kustomize"
      }
    ]
  }
```

(1) Optional: For RHEL 9 images, copy the required universal executable in the /**policy-generator/PolicyGenerator-not-fips-compliant** folder for the ArgoCD version.

(2) Match the **multicluster-operators-subscription** image to the RHACM version.

(3) In disconnected environments, replace the URL for the **multicluster-operators-subscription** image with the disconnected registry equivalent for your environment.

c. Patch the ArgoCD instance. Run the following command:

```
$ oc patch argocd openshift-gitops \
-n openshift-gitops --type=merge \
--patch-file out/argocd/deployment/argocd-openshift-gitops-patch.json
```

3. In RHACM 2.7 and later, the multicluster engine enables the **cluster-proxy-addon** feature by default. Apply the following patch to disable the **cluster-proxy-addon** feature and remove the relevant hub cluster and managed pods that are responsible for this add-on. Run the following command:

```
$ oc patch multiclusterengines.multicluster.openshift.io multiclusterengine --type=merge --
patch-file out/argocd/deployment/disable-cluster-proxy-addon.json
```

4. Apply the pipeline configuration to your hub cluster by running the following command:

```
$ oc apply -k out/argocd/deployment
```

2.9. PREPARING THE GITOPS ZTP SITE CONFIGURATION REPOSITORY

Before you can use the GitOps Zero Touch Provisioning (ZTP) pipeline, you need to prepare the Git repository to host the site configuration data.

Prerequisites

- You have configured the hub cluster GitOps applications for generating the required installation and policy custom resources (CRs).
- You have deployed the managed clusters using GitOps ZTP.

Procedure

1. Create a directory structure with separate paths for the **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** CRs.

   NOTE

   Keep **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** CRs in separate directories. Both the **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** directories must contain a **kustomization.yaml** file that explicitly includes the files in that directory.

2. Export the **argocd** directory from the **ztp-site-generate** container image using the following commands:

```
$ podman pull registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16
```

```
$ mkdir -p ./out
```

```
$ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16 extract /home/ztp --tar | tar x -C ./out
```

3. Check that the **out** directory contains the following subdirectories:
   - **out/extra-manifest** contains the source CR files that **SiteConfig** uses to generate extra manifest **configMap**.
   - **out/source-crs** contains the source CR files that **PolicyGenerator** uses to generate the Red Hat Advanced Cluster Management (RHACM) policies.
   - **out/argocd/deployment** contains patches and YAML files to apply on the hub cluster for use in the next step of this procedure.
   - **out/argocd/example** contains the examples for **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** files that represent the recommended configuration.

4. Copy the **out/source-crs** folder and contents to the **PolicyGenerator** or **PolicyGentemplate** directory.

5. The out/extra-manifests directory contains the reference manifests for a RAN DU cluster. Copy the **out/extra-manifests** directory into the **SiteConfig** folder. This directory should contain CRs from the **ztp-site-generate** container only. Do not add user-provided CRs here. If you want to work with user-provided CRs you must create another directory for that content. For example:

```
example/
  ├── acmpolicygenerator
  │   ├── kustomization.yaml
  │   └── source-crs/
  ├── policygentemplates (1)
  │   ├── kustomization.yaml
  │   └── source-crs/
  └── siteconfig
        ├── extra-manifests
        └── kustomization.yaml
```

1 Using **PolicyGenTemplate** CRs to manage and deploy polices to manage clusters will be deprecated in a future OpenShift Container Platform release. Equivalent and improved functionality is available by using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

6. Commit the directory structure and the **kustomization.yaml** files and push to your Git repository. The initial push to Git should include the **kustomization.yaml** files.

You can use the directory structure under **out/argocd/example** as a reference for the structure and content of your Git repository. That structure includes **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** reference CRs for single-node, three-node, and standard clusters. Remove references to cluster types that you are not using.

For all cluster types, you must:

- Add the **source-crs** subdirectory to the **acmpolicygenerator** or **policygentemplates** directory.
- Add the **extra-manifests** directory to the **siteconfig** directory.

The following example describes a set of CRs for a network of single-node clusters:

```
example/
  ├── acmpolicygenerator
  │   ├── acm-common-ranGen.yaml
  │   ├── acm-example-sno-site.yaml
  │   ├── acm-group-du-sno-ranGen.yaml
  │   ├── group-du-sno-validator-ranGen.yaml
  │   ├── kustomization.yaml
  │   ├── source-crs/
  │   └── ns.yaml
  └── siteconfig
      ├── example-sno.yaml
      ├── extra-manifests/ 1
      ├── custom-manifests/ 2
      ├── KlusterletAddonConfigOverride.yaml
      └── kustomization.yaml
```

1 Contains reference manifests from the **ztp-container**.

2 Contains custom manifests.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources

- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

2.10. PREPARING THE GITOPS ZTP SITE CONFIGURATION REPOSITORY FOR VERSION INDEPENDENCE

You can use GitOps ZTP to manage source custom resources (CRs) for managed clusters that are running different versions of OpenShift Container Platform. This means that the version of OpenShift Container Platform running on the hub cluster can be independent of the version running on the managed clusters.

NOTE

The following procedure assumes you are using **PolicyGenerator** resources instead of **PolicyGentemplate** resources for cluster policies management.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.

Procedure

1. Create a directory structure with separate paths for the **SiteConfig** and **PolicyGenerator** CRs.
2. Within the **PolicyGenerator** directory, create a directory for each OpenShift Container Platform version you want to make available. For each version, create the following resources:
   - **kustomization.yaml** file that explicitly includes the files in that directory
   - **source-crs** directory to contain reference CR configuration files from the **ztp-site-generate** container
     If you want to work with user-provided CRs, you must create a separate directory for them.
3. In the /**siteconfig** directory, create a subdirectory for each OpenShift Container Platform version you want to make available. For each version, create at least one directory for reference CRs to be copied from the container. There is no restriction on the naming of directories or on the number of reference directories. If you want to work with custom manifests, you must create a separate directory for them.
   The following example describes a structure using user-provided manifests and CRs for different versions of OpenShift Container Platform:

```
├── acmpolicygenerator
│   ├── kustomization.yaml 1
│   ├── version_4.13 2
│   │   ├── common-ranGen.yaml
│   │   ├── group-du-sno-ranGen.yaml
│   │   ├── group-du-sno-validator-ranGen.yaml
│   │   ├── helix56-v413.yaml
│   │   ├── kustomization.yaml 3
│   │   ├── ns.yaml
│   │   └── source-crs/ 4
│   │      └── reference-crs/ 5
│   │      └── custom-crs/ 6
│    └── version_4.14 7
│       ├── common-ranGen.yaml
│       ├── group-du-sno-ranGen.yaml
│       ├── group-du-sno-validator-ranGen.yaml
│       ├── helix56-v414.yaml
│       ├── kustomization.yaml 8
│       ├── ns.yaml
│       └── source-crs/ 9
│         └── reference-crs/ 10
│         └── custom-crs/ 11
└── siteconfig
    ├── kustomization.yaml
    ├── version_4.13
    │   ├── helix56-v413.yaml
    │   ├── kustomization.yaml
    │   ├── extra-manifest/ 12
    │   └── custom-manifest/ 13
    └── version_4.14
        ├── helix57-v414.yaml
        ├── kustomization.yaml
        ├── extra-manifest/ 14
        └── custom-manifest/ 15
```

1 Create a top-level **kustomization** YAML file.

2 7 Create the version-specific directories within the custom /**acmpolicygenerator** directory.

3 8 Create a **kustomization.yaml** file for each version.

4 9 Create a **source-crs** directory for each version to contain reference CRs from the **ztp-site-generate** container.

5 10 Create the **reference-crs** directory for policy CRs that are extracted from the ZTP container.

6 11 Optional: Create a **custom-crs** directory for user-provided CRs.

12 14 Create a directory within the custom /**siteconfig** directory to contain extra manifests from the **ztp-site-generate** container.

13 15 Create a folder to hold user-provided manifests.

NOTE

In the previous example, each version subdirectory in the custom /**siteconfig** directory contains two further subdirectories, one containing the reference manifests copied from the container, the other for custom manifests that you provide. The names assigned to those directories are examples. If you use user-provided CRs, the last directory listed under **extraManifests.searchPaths** in the **SiteConfig** CR must be the directory containing user-provided CRs.

4. Edit the **SiteConfig** CR to include the search paths of any directories you have created. The first directory that is listed under **extraManifests.searchPaths** must be the directory containing the reference manifests. Consider the order in which the directories are listed. In cases where

directories contain files with the same name, the file in the final directory takes precedence.

Example SiteConfig CR

```
extraManifests:
    searchPaths:
    - extra-manifest/ (1)
    - custom-manifest/ (2)
```

(1) The directory containing the reference manifests must be listed first under **extraManifests.searchPaths**.

(2) If you are using user-provided CRs, the last directory listed under **extraManifests.searchPaths** in the **SiteConfig** CR must be the directory containing those user-provided CRs.

5. Edit the top-level **kustomization.yaml** file to control which OpenShift Container Platform versions are active. The following is an example of a **kustomization.yaml** file at the top level:

```
resources:
- version_4.13 (1)
#- version_4.14 (2)
```

(1) Activate version 4.13.

(2) Use comments to deactivate a version.

CHAPTER 3. UPDATING GITOPS ZTP

You can update the GitOps Zero Touch Provisioning (ZTP) infrastructure independently from the hub cluster, Red Hat Advanced Cluster Management (RHACM), and the managed OpenShift Container Platform clusters.

NOTE

You can update the Red Hat OpenShift GitOps Operator when new versions become available. When updating the GitOps ZTP plugin, review the updated files in the reference configuration and ensure that the changes meet your requirements.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

3.1. OVERVIEW OF THE GITOPS ZTP UPDATE PROCESS

You can update GitOps Zero Touch Provisioning (ZTP) for a fully operational hub cluster running an earlier version of the GitOps ZTP infrastructure. The update process avoids impact on managed clusters.

NOTE

Any changes to policy settings, including adding recommended content, results in updated polices that must be rolled out to the managed clusters and reconciled.

At a high level, the strategy for updating the GitOps ZTP infrastructure is as follows:

1. Label all existing clusters with the **ztp-done** label.
2. Stop the ArgoCD applications.
3. Install the new GitOps ZTP tools.
4. Update required content and optional changes in the Git repository.
5. Update and restart the application configuration.

3.2. PREPARING FOR THE UPGRADE

Use the following procedure to prepare your site for the GitOps Zero Touch Provisioning (ZTP) upgrade.

Procedure

1. Get the latest version of the GitOps ZTP container that has the custom resources (CRs) used to configure Red Hat OpenShift GitOps for use with GitOps ZTP.

2. Extract the **argocd/deployment** directory by using the following commands:

   ```
   $ mkdir -p ./update
   ```

   ```
   $ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16 extract /home/ztp --tar | tar x -C ./update
   ```

   The /**update** directory contains the following subdirectories:

   - **update/extra-manifest**: contains the source CR files that the **SiteConfig** CR uses to generate the extra manifest **configMap**.
   - **update/source-crs**: contains the source CR files that the **PolicyGenerator** or **PolicyGentemplate** CR uses to generate the Red Hat Advanced Cluster Management (RHACM) policies.
   - **update/argocd/deployment**: contains patches and YAML files to apply on the hub cluster for use in the next step of this procedure.
   - **update/argocd/example**: contains example **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** files that represent the recommended configuration.

3. Update the **clusters-app.yaml** and **policies-app.yaml** files to reflect the name of your applications and the URL, branch, and path for your Git repository.
   If the upgrade includes changes that results in obsolete policies, the obsolete policies should be removed prior to performing the upgrade.

4. Diff the changes between the configuration and deployment source CRs in the /**update** folder and Git repo where you manage your fleet site CRs. Apply and push the required changes to your site repository.

   IMPORTANT

   When you update GitOps ZTP to the latest version, you must apply the changes from the **update/argocd/deployment** directory to your site repository. Do not use older versions of the **argocd/deployment/** files.

3.3. LABELING THE EXISTING CLUSTERS

To ensure that existing clusters remain untouched by the tool updates, label all existing managed clusters with the **ztp-done** label.

NOTE

This procedure only applies when updating clusters that were not provisioned with Topology Aware Lifecycle Manager (TALM). Clusters that you provision with TALM are automatically labeled with **ztp-done**.

Procedure

1. Find a label selector that lists the managed clusters that were deployed with GitOps Zero Touch Provisioning (ZTP), such as **local-cluster!=true**:

```
$ oc get managedcluster -l 'local-cluster!=true'
```

2. Ensure that the resulting list contains all the managed clusters that were deployed with GitOps ZTP, and then use that selector to add the **ztp-done** label:

```
$ oc label managedcluster -l 'local-cluster!=true' ztp-done=
```

3.4. STOPPING THE EXISTING GITOPS ZTP APPLICATIONS

Removing the existing applications ensures that any changes to existing content in the Git repository are not rolled out until the new version of the tools is available.

Use the application files from the **deployment** directory. If you used custom names for the applications, update the names in these files first.

Procedure

1. Perform a non-cascaded delete on the **clusters** application to leave all generated resources in place:

```
$ oc delete -f update/argocd/deployment/clusters-app.yaml
```

2. Perform a cascaded delete on the **policies** application to remove all previous policies:

```
$ oc patch -f policies-app.yaml -p '{"metadata": {"finalizers": ["resources-
finalizer.argocd.argoproj.io"]}}' --type merge
```

```
$ oc delete -f update/argocd/deployment/policies-app.yaml
```

3.5. REQUIRED CHANGES TO THE GIT REPOSITORY

When upgrading the **ztp-site-generate** container from an earlier release of GitOps Zero Touch Provisioning (ZTP) to 4.10 or later, there are additional requirements for the contents of the Git repository. Existing content in the repository must be updated to reflect these changes.

NOTE

The following procedure assumes you are using **PolicyGenerator** resources instead of **PolicyGentemplate** resources for cluster policies management.

- Make required changes to **PolicyGenerator** files:

All **PolicyGenerator** files must be created in a **Namespace** prefixed with **ztp**. This ensures that the GitOps ZTP application is able to manage the policy CRs generated by GitOps ZTP without conflicting with the way Red Hat Advanced Cluster Management (RHACM) manages the policies internally.

- Add the **kustomization.yaml** file to the repository:
  All **SiteConfig** and **PolicyGenerator** CRs must be included in a **kustomization.yaml** file under their respective directory trees. For example:

```
├── acmpolicygenerator
│   ├── site1-ns.yaml
│   ├── site1.yaml
│   ├── site2-ns.yaml
│   ├── site2.yaml
│   ├── common-ns.yaml
│   ├── common-ranGen.yaml
│   ├── group-du-sno-ranGen-ns.yaml
│   ├── group-du-sno-ranGen.yaml
│   └── kustomization.yaml
└── siteconfig
    ├── site1.yaml
    ├── site2.yaml
    └── kustomization.yaml
```

NOTE

The files listed in the **generator** sections must contain either **SiteConfig** or **{policy-gen-cr}** CRs only. If your existing YAML files contain other CRs, for example, **Namespace**, these other CRs must be pulled out into separate files and listed in the **resources** section.

The **PolicyGenerator** kustomization file must contain all **PolicyGenerator** YAML files in the **generator** section and **Namespace** CRs in the **resources** section. For example:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

generators:
- acm-common-ranGen.yaml
- acm-group-du-sno-ranGen.yaml
- site1.yaml
- site2.yaml

resources:
- common-ns.yaml
- acm-group-du-sno-ranGen-ns.yaml
- site1-ns.yaml
- site2-ns.yaml
```

The **SiteConfig** kustomization file must contain all **SiteConfig** YAML files in the **generator** section and any other CRs in the resources:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
```

```
generators:
- site1.yaml
- site2.yaml
```

- Remove the **pre-sync.yaml** and **post-sync.yaml** files.
  In OpenShift Container Platform 4.10 and later, the **pre-sync.yaml** and **post-sync.yaml** files are no longer required. The **update/deployment/kustomization.yaml** CR manages the policies deployment on the hub cluster.

  NOTE

  There is a set of **pre-sync.yaml** and **post-sync.yaml** files under both the **SiteConfig** and **{policy-gen-cr}** trees.

- Review and incorporate recommended changes
  Each release may include additional recommended changes to the configuration applied to deployed clusters. Typically these changes result in lower CPU use by the OpenShift platform, additional features, or improved tuning of the platform.

  Review the reference **SiteConfig** and **PolicyGenerator** CRs applicable to the types of cluster in your network. These examples can be found in the **argocd/example** directory extracted from the GitOps ZTP container.

3.6. INSTALLING THE NEW GITOPS ZTP APPLICATIONS

Using the extracted **argocd/deployment** directory, and after ensuring that the applications point to your site Git repository, apply the full contents of the deployment directory. Applying the full contents of the directory ensures that all necessary resources for the applications are correctly configured.

Procedure

1. To install the GitOps ZTP plugin, patch the ArgoCD instance in the hub cluster with the relevant multicluster engine (MCE) subscription image. Customize the patch file that you previously extracted into the **out/argocd/deployment/** directory for your environment.

   a. Select the **multicluster-operators-subscription** image that matches your RHACM version.

Table 3.1. **multicluster-operators-subscription** image versions

OpenShift Container Platform version	RHACM version	MCE version	MCE RHEL version	MCE image
4.14, 4.15, 4.16	2.8, 2.9	2.8, 2.9	RHEL 8	**registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel8:v2.8** **registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel8:v2.9**

OpenShift Container Platform version	RHACM version	MCE version	MCE RHEL version	MCE image
4.14, 4.15, 4.16	2.10	2.10	RHEL 9	**registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel9:v2.10**

IMPORTANT

The version of the **multicluster-operators-subscription** image should match the RHACM version. Beginning with the MCE 2.10 release, RHEL 9 is the base image for **multicluster-operators-subscription** images.

b. Add the following configuration to the **out/argocd/deployment/argocd-openshift-gitops-patch.json** file:

```
{
  "args": [
    "-c",
    "mkdir -p /.config/kustomize/plugin/policy.open-cluster-
management.io/v1/policygenerator && cp /policy-generator/PolicyGenerator-not-fips-
compliant /.config/kustomize/plugin/policy.open-cluster-
management.io/v1/policygenerator/PolicyGenerator" 1
  ],
  "command": [
    "/bin/bash"
  ],
  "image": "registry.redhat.io/rhacm2/multicluster-operators-subscription-rhel9:v2.10", 2
3
  "name": "policy-generator-install",
  "imagePullPolicy": "Always",
  "volumeMounts": [
    {
      "mountPath": "/.config",
      "name": "kustomize"
    }
  ]
}
```

1 Optional: For RHEL 9 images, copy the required universal executable in the **/policy-generator/PolicyGenerator-not-fips-compliant** folder for the ArgoCD version.

2 Match the **multicluster-operators-subscription** image to the RHACM version.

3 In disconnected environments, replace the URL for the **multicluster-operators-subscription** image with the disconnected registry equivalent for your environment.

c. Patch the ArgoCD instance. Run the following command:

```
$ oc patch argocd openshift-gitops \
-n openshift-gitops --type=merge \
--patch-file out/argocd/deployment/argocd-openshift-gitops-patch.json
```

2. In RHACM 2.7 and later, the multicluster engine enables the **cluster-proxy-addon** feature by default. Apply the following patch to disable the **cluster-proxy-addon** feature and remove the relevant hub cluster and managed pods that are responsible for this add-on. Run the following command:

```
$ oc patch multiclusterengines.multicluster.openshift.io multiclusterengine --type=merge --
patch-file out/argocd/deployment/disable-cluster-proxy-addon.json
```

3. Apply the pipeline configuration to your hub cluster by running the following command:

```
$ oc apply -k out/argocd/deployment
```

3.7. ROLLING OUT THE GITOPS ZTP CONFIGURATION CHANGES

If any configuration changes were included in the upgrade due to implementing recommended changes, the upgrade process results in a set of policy CRs on the hub cluster in the **Non-Compliant** state. With the GitOps Zero Touch Provisioning (ZTP) version 4.10 and later **ztp-site-generate** container, these policies are set to **inform** mode and are not pushed to the managed clusters without an additional step by the user. This ensures that potentially disruptive changes to the clusters can be managed in terms of when the changes are made, for example, during a maintenance window, and how many clusters are updated concurrently.

To roll out the changes, create one or more **ClusterGroupUpgrade** CRs as detailed in the TALM documentation. The CR must contain the list of **Non-Compliant** policies that you want to push out to the managed clusters as well as a list or selector of which clusters should be included in the update.

Additional resources

- For information about the Topology Aware Lifecycle Manager (TALM), see About the Topology Aware Lifecycle Manager configuration.
- For information about creating **ClusterGroupUpgrade** CRs, see About the auto-created ClusterGroupUpgrade CR for GitOps ZTP.

CHAPTER 4. INSTALLING MANAGED CLUSTERS WITH RHACM AND SITECONFIG RESOURCES

You can provision OpenShift Container Platform clusters at scale with Red Hat Advanced Cluster Management (RHACM) using the assisted service and the GitOps plugin policy generator with core-reduction technology enabled. The GitOps Zero Touch Provisioning (ZTP) pipeline performs the cluster installations. GitOps ZTP can be used in a disconnected environment.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

4.1. GITOPS ZTP AND TOPOLOGY AWARE LIFECYCLE MANAGER

GitOps Zero Touch Provisioning (ZTP) generates installation and configuration CRs from manifests stored in Git. These artifacts are applied to a centralized hub cluster where Red Hat Advanced Cluster Management (RHACM), the assisted service, and the Topology Aware Lifecycle Manager (TALM) use the CRs to install and configure the managed cluster. The configuration phase of the GitOps ZTP pipeline uses the TALM to orchestrate the application of the configuration CRs to the cluster. There are several key integration points between GitOps ZTP and the TALM.

Inform policies

By default, GitOps ZTP creates all policies with a remediation action of **inform**. These policies cause RHACM to report on compliance status of clusters relevant to the policies but does not apply the desired configuration. During the GitOps ZTP process, after OpenShift installation, the TALM steps through the created **inform** policies and enforces them on the target managed cluster(s). This applies the configuration to the managed cluster. Outside of the GitOps ZTP phase of the cluster lifecycle, this allows you to change policies without the risk of immediately rolling those changes out to affected managed clusters. You can control the timing and the set of remediated clusters by using TALM.

Automatic creation of ClusterGroupUpgrade CRs

To automate the initial configuration of newly deployed clusters, TALM monitors the state of all **ManagedCluster** CRs on the hub cluster. Any **ManagedCluster** CR that does not have a **ztp-done** label applied, including newly created **ManagedCluster** CRs, causes the TALM to automatically create a **ClusterGroupUpgrade** CR with the following characteristics:

- The **ClusterGroupUpgrade** CR is created and enabled in the **ztp-install** namespace.
- **ClusterGroupUpgrade** CR has the same name as the **ManagedCluster** CR.
- The cluster selector includes only the cluster associated with that **ManagedCluster** CR.

- The set of managed policies includes all policies that RHACM has bound to the cluster at the time the **ClusterGroupUpgrade** is created.
- Pre-caching is disabled.
- Timeout set to 4 hours (240 minutes).

The automatic creation of an enabled **ClusterGroupUpgrade** ensures that initial zero-touch deployment of clusters proceeds without the need for user intervention. Additionally, the automatic creation of a **ClusterGroupUpgrade** CR for any **ManagedCluster** without the **ztp-done** label allows a failed GitOps ZTP installation to be restarted by simply deleting the **ClusterGroupUpgrade** CR for the cluster.

Waves

Each policy generated from a **PolicyGenerator** or **PolicyGentemplate** CR includes a **ztp-deploy-wave** annotation. This annotation is based on the same annotation from each CR which is included in that policy. The wave annotation is used to order the policies in the auto-generated **ClusterGroupUpgrade** CR. The wave annotation is not used other than for the auto-generated **ClusterGroupUpgrade** CR.

NOTE

All CRs in the same policy must have the same setting for the **ztp-deploy-wave** annotation. The default value of this annotation for each CR can be overridden in the **PolicyGenerator** or **PolicyGentemplate**. The wave annotation in the source CR is used for determining and setting the policy wave annotation. This annotation is removed from each built CR which is included in the generated policy at runtime.

The TALM applies the configuration policies in the order specified by the wave annotations. The TALM waits for each policy to be compliant before moving to the next policy. It is important to ensure that the wave annotation for each CR takes into account any prerequisites for those CRs to be applied to the cluster. For example, an Operator must be installed before or concurrently with the configuration for the Operator. Similarly, the **CatalogSource** for an Operator must be installed in a wave before or concurrently with the Operator Subscription. The default wave value for each CR takes these prerequisites into account.

Multiple CRs and policies can share the same wave number. Having fewer policies can result in faster deployments and lower CPU usage. It is a best practice to group many CRs into relatively few waves.

To check the default wave value in each source CR, run the following command against the **out/source-crs** directory that is extracted from the **ztp-site-generate** container image:

```
$ grep -r "ztp-deploy-wave" out/source-crs
```

Phase labels

The **ClusterGroupUpgrade** CR is automatically created and includes directives to annotate the **ManagedCluster** CR with labels at the start and end of the GitOps ZTP process.
When GitOps ZTP configuration postinstallation commences, the **ManagedCluster** has the **ztp-running** label applied. When all policies are remediated to the cluster and are fully compliant, these directives cause the TALM to remove the **ztp-running** label and apply the **ztp-done** label.

For deployments that make use of the **informDuValidator** policy, the **ztp-done** label is applied when the cluster is fully ready for deployment of applications. This includes all reconciliation and resulting effects of the GitOps ZTP applied configuration CRs. The **ztp-done** label affects automatic **ClusterGroupUpgrade** CR creation by TALM. Do not manipulate this label after the initial GitOps ZTP installation of the cluster.

Linked CRs

The automatically created **ClusterGroupUpgrade** CR has the owner reference set as the **ManagedCluster** from which it was derived. This reference ensures that deleting the **ManagedCluster** CR causes the instance of the **ClusterGroupUpgrade** to be deleted along with any supporting resources.

4.2. OVERVIEW OF DEPLOYING MANAGED CLUSTERS WITH GITOPS ZTP

Red Hat Advanced Cluster Management (RHACM) uses GitOps Zero Touch Provisioning (ZTP) to deploy single-node OpenShift Container Platform clusters, three-node clusters, and standard clusters. You manage site configuration data as OpenShift Container Platform custom resources (CRs) in a Git repository. GitOps ZTP uses a declarative GitOps approach for a develop once, deploy anywhere model to deploy the managed clusters.

The deployment of the clusters includes:

- Installing the host operating system (RHCOS) on a blank server
- Deploying OpenShift Container Platform
- Creating cluster policies and site subscriptions
- Making the necessary network configurations to the server operating system
- Deploying profile Operators and performing any needed software-related configuration, such as performance profile, PTP, and SR-IOV

Overview of the managed site installation process

After you apply the managed site custom resources (CRs) on the hub cluster, the following actions happen automatically:

1. A Discovery image ISO file is generated and booted on the target host.
2. When the ISO file successfully boots on the target host it reports the host hardware information to RHACM.
3. After all hosts are discovered, OpenShift Container Platform is installed.
4. When OpenShift Container Platform finishes installing, the hub installs the **klusterlet** service on the target cluster.
5. The requested add-on services are installed on the target cluster.

The Discovery image ISO process is complete when the **Agent** CR for the managed cluster is created on the hub cluster.

IMPORTANT

The target bare-metal host must meet the networking, firmware, and hardware requirements listed in Recommended single-node OpenShift cluster configuration for vDU application workloads.

4.3. CREATING THE MANAGED BARE-METAL HOST SECRETS

Add the required **Secret** custom resources (CRs) for the managed bare-metal host to the hub cluster. You need a secret for the GitOps Zero Touch Provisioning (ZTP) pipeline to access the Baseboard Management Controller (BMC) and a secret for the assisted installer service to pull cluster installation images from the registry.

NOTE

The secrets are referenced from the **SiteConfig** CR by name. The namespace must match the **SiteConfig** namespace.

Procedure

1. Create a YAML secret file containing credentials for the host Baseboard Management Controller (BMC) and a pull secret required for installing OpenShift and all add-on cluster Operators:

   a. Save the following YAML as the file **example-sno-secret.yaml**:

```
apiVersion: v1
kind: Secret
metadata:
  name: example-sno-bmc-secret
  namespace: example-sno (1)
data: (2)
  password: <base64_password>
  username: <base64_username>
type: Opaque
---
apiVersion: v1
kind: Secret
metadata:
  name: pull-secret
  namespace: example-sno (3)
data:
  .dockerconfigjson: <pull_secret> (4)
type: kubernetes.io/dockerconfigjson
```

(1) Must match the namespace configured in the related **SiteConfig** CR

(2) Base64-encoded values for **password** and **username**

(3) Must match the namespace configured in the related **SiteConfig** CR

(4) Base64-encoded pull secret

2. Add the relative path to **example-sno-secret.yaml** to the **kustomization.yaml** file that you use to install the cluster.

4.4. CONFIGURING DISCOVERY ISO KERNEL ARGUMENTS FOR INSTALLATIONS USING GITOPS ZTP

The GitOps Zero Touch Provisioning (ZTP) workflow uses the Discovery ISO as part of the OpenShift Container Platform installation process on managed bare-metal hosts. You can edit the **InfraEnv** resource to specify kernel arguments for the Discovery ISO. This is useful for cluster installations with specific environmental requirements. For example, configure the **rd.net.timeout.carrier** kernel argument for the Discovery ISO to facilitate static networking for the cluster or to receive a DHCP address before downloading the root file system during installation.

NOTE

In OpenShift Container Platform 4.16, you can only add kernel arguments. You can not replace or delete kernel arguments.

Prerequisites

- You have installed the OpenShift CLI (oc).
- You have logged in to the hub cluster as a user with cluster-admin privileges.

Procedure

1. Create the **InfraEnv** CR and edit the **spec.kernelArguments** specification to configure kernel arguments.

   a. Save the following YAML in an **InfraEnv-example.yaml** file:

      NOTE

      The **InfraEnv** CR in this example uses template syntax such as **{{ .Cluster.ClusterName }}** that is populated based on values in the **SiteConfig** CR. The **SiteConfig** CR automatically populates values for these templates during deployment. Do not edit the templates manually.

```
apiVersion: agent-install.openshift.io/v1beta1
kind: InfraEnv
metadata:
  annotations:
    argocd.argoproj.io/sync-wave: "1"
  name: "{{ .Cluster.ClusterName }}"
  namespace: "{{ .Cluster.ClusterName }}"
spec:
  clusterRef:
    name: "{{ .Cluster.ClusterName }}"
    namespace: "{{ .Cluster.ClusterName }}"
  kernelArguments:
    - operation: append 1
      value: audit=0 2
    - operation: append
```

```
      value: trace=1
  sshAuthorizedKey: "{{ .Site.SshPublicKey }}"
  proxy: "{{ .Cluster.ProxySettings }}"
  pullSecretRef:
    name: "{{ .Site.PullSecretRef.Name }}"
  ignitionConfigOverride: "{{ .Cluster.IgnitionConfigOverride }}"
  nmStateConfigLabelSelector:
    matchLabels:
      nmstate-label: "{{ .Cluster.ClusterName }}"
  additionalNTPSources: "{{ .Cluster.AdditionalNTPSources }}"
```

1 Specify the append operation to add a kernel argument.

2 Specify the kernel argument you want to configure. This example configures the audit kernel argument and the trace kernel argument.

2. Commit the **InfraEnv-example.yaml** CR to the same location in your Git repository that has the **SiteConfig** CR and push your changes. The following example shows a sample Git repository structure:

   ```
   ~/example-ztp/install
             └── site-install
                  ├── siteconfig-example.yaml
                  ├── InfraEnv-example.yaml
                 ...
   ```

3. Edit the **spec.clusters.crTemplates** specification in the **SiteConfig** CR to reference the **InfraEnv-example.yaml** CR in your Git repository:

   ```
   clusters:
     crTemplates:
       InfraEnv: "InfraEnv-example.yaml"
   ```

   When you are ready to deploy your cluster by committing and pushing the **SiteConfig** CR, the build pipeline uses the custom **InfraEnv-example** CR in your Git repository to configure the infrastructure environment, including the custom kernel arguments.

Verification

To verify that the kernel arguments are applied, after the Discovery image verifies that OpenShift Container Platform is ready for installation, you can SSH to the target host before the installation process begins. At that point, you can view the kernel arguments for the Discovery ISO in the **/proc/cmdline** file.

1. Begin an SSH session with the target host:

   ```
   $ ssh -i /path/to/privatekey core@<host_name>
   ```

2. View the system's kernel arguments by using the following command:

   ```
   $ cat /proc/cmdline
   ```

4.5. DEPLOYING A MANAGED CLUSTER WITH SITECONFIG AND GITOPS ZTP

Use the following procedure to create a **SiteConfig** custom resource (CR) and related files and initiate the GitOps Zero Touch Provisioning (ZTP) cluster deployment.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You configured the hub cluster for generating the required installation and policy CRs.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and you must configure it as a source repository for the ArgoCD application. See "Preparing the GitOps ZTP site configuration repository" for more information.

  NOTE

  When you create the source repository, ensure that you patch the ArgoCD application with the **argocd/deployment/argocd-openshift-gitops-patch.json** patch-file that you extract from the **ztp-site-generate** container. See "Configuring the hub cluster with ArgoCD".

- To be ready for provisioning managed clusters, you require the following for each bare-metal host:

  Network connectivity

  Your network requires DNS. Managed cluster hosts should be reachable from the hub cluster. Ensure that Layer 3 connectivity exists between the hub cluster and the managed cluster host.

  Baseboard Management Controller (BMC) details

  GitOps ZTP uses BMC username and password details to connect to the BMC during cluster installation. The GitOps ZTP plugin manages the **ManagedCluster** CRs on the hub cluster based on the **SiteConfig** CR in your site Git repo. You create individual **BMCSecret** CRs for each host manually.

Procedure

1. Create the required managed cluster secrets on the hub cluster. These resources must be in a namespace with a name matching the cluster name. For example, in **out/argocd/example/siteconfig/example-sno.yaml**, the cluster name and namespace is **example-sno**.

   a. Export the cluster namespace by running the following command:

   ```
   $ export CLUSTERNS=example-sno
   ```

   b. Create the namespace:

   ```
   $ oc create namespace $CLUSTERNS
   ```

2. Create pull secret and BMC **Secret** CRs for the managed cluster. The pull secret must contain all the credentials necessary for installing OpenShift Container Platform and all required Operators. See "Creating the managed bare-metal host secrets" for more information.

   NOTE

   The secrets are referenced from the **SiteConfig** custom resource (CR) by name. The namespace must match the **SiteConfig** namespace.

3. Create a **SiteConfig** CR for your cluster in your local clone of the Git repository:

   a. Choose the appropriate example for your CR from the **out/argocd/example/siteconfig/** folder. The folder includes example files for single node, three-node, and standard clusters:

      - **example-sno.yaml**
      - **example-3node.yaml**
      - **example-standard.yaml**

   b. Change the cluster and host details in the example file to match the type of cluster you want. For example:

      Example single-node OpenShift SiteConfig CR

```
# example-node1-bmh-secret & assisted-deployment-pull-secret need to be created
under same namespace example-sno
---
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "example-sno"
  namespace: "example-sno"
spec:
  baseDomain: "example.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
  clusterImageSetNameRef: "openshift-4.10"
  sshPublicKey: "ssh-rsa AAAA..."
  clusters:
  - clusterName: "example-sno"
    networkType: "OVNKubernetes"
    # installConfigOverrides is a generic way of passing install-config
    # parameters through the siteConfig.  The 'capabilities' field configures
    # the composable openshift feature.  In this 'capabilities' setting, we
    # remove all but the marketplace component from the optional set of
    # components.
    # Notes:
    # - OperatorLifecycleManager is needed for 4.15 and later
    # - NodeTuning is needed for 4.13 and later, not for 4.12 and earlier
    # - Ingress is needed for 4.16 and later
    installConfigOverrides: |
      {
        "capabilities": {
          "baselineCapabilitySet": "None",
          "additionalEnabledCapabilities": [
          "NodeTuning",
          "OperatorLifecycleManager"
          "Ingress"
        ]
      }
    }
  # It is strongly recommended to include crun manifests as part of the additional install-
time manifests for 4.13+.
  # The crun manifests can be obtained from source-crs/optional-extra-manifest/ and
added to the git repo ie.sno-extra-manifest.
  # extraManifestPath: sno-extra-manifest
  clusterLabels:
    # These example cluster labels correspond to the bindingRules in the
PolicyGenTemplate examples
    du-profile: "latest"
    # These example cluster labels correspond to the bindingRules in the
PolicyGenTemplate examples in ../policygentemplates:
    # ../policygentemplates/common-ranGen.yaml will apply to all clusters with 'common:
true'
    common: true
    # ../policygentemplates/group-du-sno-ranGen.yaml will apply to all clusters with
'group-du-sno: ""'
    group-du-sno: ""
    # ../policygentemplates/example-sno-site.yaml will apply to all clusters with 'sites:
"example-sno"'
    # Normally this should match or contain the cluster name so it only applies to a single
cluster
    sites : "example-sno"
  clusterNetwork:
    - cidr: 1001:1::/48
      hostPrefix: 64
  machineNetwork:
    - cidr: 1111:2222:3333:4444::/64
  serviceNetwork:
    - 1001:2::/112
  additionalNTPSources:
    - 1111:2222:3333:4444::2
  # Initiates the cluster for workload partitioning. Setting specific reserved/isolated
CPUSets is done via PolicyTemplate
  # please see Workload Partitioning Feature for a complete guide.
  cpuPartitioningMode: AllNodes
  # Optionally; This can be used to override the KlusterletAddonConfig that is created for
this cluster:
  #crTemplates:
  #  KlusterletAddonConfig: "KlusterletAddonConfigOverride.yaml"
  nodes:
    - hostName: "example-node1.example.com"
      role: "master"
      # Optionally; This can be used to configure desired BIOS setting on a host:
      #biosConfigRef:
      #  filePath: "example-hw.profile"
      bmcAddress: "idrac-
virtualmedia+https://[1111:2222:3333:4444::bbbb:1]/redfish/v1/Systems/System.Embedded.
1"
      bmcCredentialsName:
        name: "example-node1-bmh-secret"
        bootMACAddress: "AA:BB:CC:DD:EE:11"
        # Use UEFISecureBoot to enable secure boot
        bootMode: "UEFI"
        rootDeviceHints:
          deviceName: "/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0"
        # disk partition at `/var/lib/containers` with ignitionConfigOverride. Some values
must be updated. See DiskPartitionContainer.md for more details
        ignitionConfigOverride: |
          {
           "ignition": {
             "version": "3.2.0"
           },
           "storage": {
             "disks": [
               {
                 "device": "/dev/disk/by-id/wwn-0x6b07b250ebb9d0002a33509f24af1f62",
                 "partitions": [
                   {
                    "label": "var-lib-containers",
                    "sizeMiB": 0,
                    "startMiB": 250000
                   }
                 ],
                 "wipeTable": false
                }
              ],
           "filesystems": [
             {
              "device": "/dev/disk/by-partlabel/var-lib-containers",
              "format": "xfs",
              "mountOptions": [
                "defaults",
                "prjquota"
               ],
               "path": "/var/lib/containers",
               "wipeFilesystem": true
              }
            ]
          },
          "systemd": {
            "units": [
              {
               "contents": "# Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-
disk-by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/b
y-partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-
fs.target",
               "enabled": true,
               "name": "var-lib-containers.mount"
              }
             ]
           }
          }
        nodeNetwork:
```

```
      interfaces:
        - name: eno1
          macAddress: "AA:BB:CC:DD:EE:11"
      config:
        interfaces:
          - name: eno1
            type: ethernet
            state: up
            ipv4:
              enabled: false
            ipv6:
              enabled: true
              address:
              # For SNO sites with static IP addresses, the node-specific,
              # API and Ingress IPs should all be the same and configured on
              # the interface
              - ip: 1111:2222:3333:4444::aaaa:1
                prefix-length: 64
        dns-resolver:
          config:
            search:
            - example.com
            server:
            - 1111:2222:3333:4444::2
        routes:
          config:
          - destination: ::/0
            next-hop-interface: eno1
            next-hop-address: 1111:2222:3333:4444::1
            table-id: 254
```

NOTE

For more information about BMC addressing, see the "Additional resources" section. The **installConfigOverrides** and **ignitionConfigOverride** fields are expanded in the example for ease of readability.

c. You can inspect the default set of extra-manifest **MachineConfig** CRs in **out/argocd/extra-manifest**. It is automatically applied to the cluster when it is installed.

d. Optional: To provision additional install-time manifests on the provisioned cluster, create a directory in your Git repository, for example, **sno-extra-manifest/**, and add your custom manifest CRs to this directory. If your **SiteConfig.yaml** refers to this directory in the **extraManifestPath** field, any CRs in this referenced directory are appended to the default set of extra manifests.

ENABLING THE CRUN OCI CONTAINER RUNTIME

For optimal cluster performance, enable crun for master and worker nodes in single-node OpenShift, single-node OpenShift with additional worker nodes, three-node OpenShift, and standard clusters.

Enable crun in a **ContainerRuntimeConfig** CR as an additional Day 0 install-time manifest to avoid the cluster having to reboot.

The **enable-crun-master.yaml** and **enable-crun-worker.yaml** CR files are in the **out/source-crs/optional-extra-manifest/** folder that you can extract from the **ztp-site-generate** container. For more information, see "Customizing extra installation manifests in the GitOps ZTP pipeline".

4. Add the **SiteConfig** CR to the **kustomization.yaml** file in the **generators** section, similar to the example shown in **out/argocd/example/siteconfig/kustomization.yaml**.

5. Commit the **SiteConfig** CR and associated **kustomization.yaml** changes in your Git repository and push the changes.
   The ArgoCD pipeline detects the changes and begins the managed cluster deployment.

Verification

- Verify that the custom roles and labels are applied after the node is deployed:

```
$ oc describe node example-node.example.com
```

Example output

```
Name:   example-node.example.com
Roles:  control-plane,example-label,master,worker
Labels: beta.kubernetes.io/arch=amd64
        beta.kubernetes.io/os=linux
        custom-label/parameter1=true
        kubernetes.io/arch=amd64
        kubernetes.io/hostname=cnfdf03.telco5gran.eng.rdu2.redhat.com
        kubernetes.io/os=linux
        node-role.kubernetes.io/control-plane=
        node-role.kubernetes.io/example-label= (1)
        node-role.kubernetes.io/master=
        node-role.kubernetes.io/worker=
        node.openshift.io/os_id=rhcos
```

(1) The custom label is applied to the node.

Additional resources

- Single-node OpenShift SiteConfig CR installation reference

4.5.1. Accelerated provisioning of GitOps ZTP

IMPORTANT

Accelerated provisioning of GitOps ZTP is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

You can reduce the time taken for cluster installation by using accelerated provisioning of GitOps ZTP for single-node OpenShift. Accelerated ZTP speeds up installation by applying Day 2 manifests derived from policies at an earlier stage.

IMPORTANT

Accelerated provisioning of GitOps ZTP is supported only when installing single-node OpenShift with Assisted Installer. Otherwise this installation method will fail.

4.5.1.1. Activating accelerated ZTP

You can activate accelerated ZTP using the **spec.clusters.clusterLabels.accelerated-ztp** label, as in the following example:

Example Accelerated ZTP SiteConfig CR.

```
apiVersion: ran.openshift.io/v2
kind: SiteConfig
metadata:
  name: "example-sno"
  namespace: "example-sno"
spec:
  baseDomain: "example.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
  clusterImageSetNameRef: "openshift-4.10"
  sshPublicKey: "ssh-rsa AAAA..."
  clusters:
  # ...
    clusterLabels:
        common: true
        group-du-sno: ""
        sites : "example-sno"
        accelerated-ztp: full
```

You can use **accelerated-ztp: full** to fully automate the accelerated process. GitOps ZTP updates the **AgentClusterInstall** resource with a reference to the accelerated GitOps ZTP **ConfigMap**, and includes resources extracted from policies by TALM, and accelerated ZTP job manifests.

If you use **accelerated-ztp: partial**, GitOps ZTP does not include the accelerated job manifests, but includes policy-derived objects created during the cluster installation of the following **kind** types:

- **PerformanceProfile.performance.openshift.io**

- **Tuned.tuned.openshift.io**
- **Namespace**
- **CatalogSource.operators.coreos.com**
- **ContainerRuntimeConfig.machineconfiguration.openshift.io**

This partial acceleration can reduce the number of reboots done by the node when applying resources of the kind **Performance Profile**, **Tuned**, and **ContainerRuntimeConfig**. TALM installs the Operator subscriptions derived from policies after RHACM completes the import of the cluster, following the same flow as standard GitOps ZTP.

The benefits of accelerated ZTP increase with the scale of your deployment. Using **accelerated-ztp: full** gives more benefit on a large number of clusters. With a smaller number of clusters, the reduction in installation time is less significant. Full accelerated ZTP leaves behind a namespace and a completed job on the spoke that need to be manually removed.

One benefit of using **accelerated-ztp: partial** is that you can override the functionality of the on-spoke job if something goes wrong with the stock implementation or if you require a custom functionality.

4.5.1.2. The accelerated ZTP process

Accelerated ZTP uses an additional **ConfigMap** to create the resources derived from policies on the spoke cluster. The standard **ConfigMap** includes manifests that the GitOps ZTP workflow uses to customize cluster installs.

TALM detects that the **accelerated-ztp** label is set and then creates a second **ConfigMap**. As part of accelerated ZTP, the **SiteConfig** generator adds a reference to that second **ConfigMap** using the naming convention **<spoke-cluster-name>-aztp**.

After TALM creates that second **ConfigMap**, it finds all policies bound to the managed cluster and extracts the GitOps ZTP profile information. TALM adds the GitOps ZTP profile information to the **<spoke-cluster-name>-aztp ConfigMap** custom resource (CR) and applies the CR to the hub cluster API.

4.5.2. Configuring IPsec encryption for single-node OpenShift clusters using GitOps ZTP and SiteConfig resources

You can enable IPsec encryption in managed single-node OpenShift clusters that you install using GitOps ZTP and Red Hat Advanced Cluster Management (RHACM). You can encrypt external traffic between pods and IPsec endpoints external to the managed cluster. All pod-to-pod network traffic between nodes on the OVN-Kubernetes cluster network is encrypted with IPsec in Transport mode.

NOTE

In OpenShift Container Platform 4.16, deploying IPsec encryption by using GitOps ZTP and RHACM is validated for single-node OpenShift clusters only.

The GitOps ZTP IPsec implementation assumes you are deploying to a resource constrained platform. As such, you install the feature with a single **MachineConfig** CR only, and you do not need to install the NMState Operator on the single-node OpenShift cluster as a prerequisite.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have configured RHACM and the hub cluster for generating the required installation and policy custom resources (CRs) for managed clusters.
- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.
- You have installed the **butane** utility, version 0.20.0 or higher.
- You have a PKCS#12 certificate for the IPsec endpoint and a CA cert in PEM format.

Procedure

1. Extract the latest version of the **ztp-site-generate** container source and merge it with your repository where you manage your custom site configuration data.

2. Configure **optional-extra-manifest/ipsec/ipsec-endpoint-config.yaml** with the required values that configure IPsec in the cluster. For example:

```
interfaces:
- name: hosta_conn
  type: ipsec
  libreswan:
    left: <cluster_node> 1
    leftid: '%fromcert'
    leftmodecfgclient: false
    leftcert: <left_cert> 2
    leftrsasigkey: '%cert'
    right: <external_host> 3
    rightid: '%fromcert'
    rightrsasigkey: '%cert'
    rightsubnet: <external_address> 4
    ikev2: insist 5
    type: tunnel
```

1. Replace **<cluster_node>** with the IP address or DNS hostname of the cluster node for the cluster-side IPsec tunnel.
2. Replace **<left_cert>** with the IPsec certificate nickname.
3. Replace **<external_host>** with the external host IP address or DNS hostname.
4. Replace **<external_address>** with the IP address or subnet of the external host on the other side of the IPsec tunnel.
5. Use the IKEv2 VPN encryption protocol only. Do not use IKEv1, which is deprecated.

3. Add your **ca.pem** and **left_server.p12** certificates to the **optional-extra-manifest/ipsec** folder. The certificate files are required for the Network Security Services (NSS) database on each host. These files are imported as part of the Butane configuration in later steps.

   a. **left_server.p12**: The certificate bundle for the IPsec endpoints

a. **left_server.p12**: The certificate bundle for the IPsec endpoints

b. **ca.pem**: The certificate authority that you signed your certificates with

4. Open a shell prompt at the **optional-extra-manifest/ipsec** folder of the Git repository where you maintain your custom site configuration data.

5. Run the **optional-extra-manifest/ipsec/build.sh** script to generate the required Butane and **MachineConfig** CRs files.

Example output

```
out
 └── argocd
      └── example
           └── optional-extra-manifest
                └── ipsec
                     ├── 99-ipsec-master-endpoint-config.bu (1)
                     ├── 99-ipsec-master-endpoint-config.yaml
                     ├── 99-ipsec-worker-endpoint-config.bu
                     ├── 99-ipsec-worker-endpoint-config.yaml
                     ├── build.sh
                     ├── ca.pem (2)
                     ├── left_server.p12
                     ├── enable-ipsec.yaml
                     ├── ipsec-endpoint-config.yml
                     └── README.md
```

(1) The **ipsec/build.sh** script generates the Butane and endpoint configuration CRs.

(2) You provide **ca.pem** and **left_server.p12** certificate files that are relevant to your network.

6. Create a **custom-manifest/** folder in the repository where you manage your custom site configuration data. Add the **enable-ipsec.yaml** and **99-ipsec-*** YAML files to the directory. For example:

```
siteconfig
  ├── site1-sno-du.yaml
  ├── extra-manifest/
  └── custom-manifest
        ├── enable-ipsec.yaml
        ├── 99-ipsec-worker-endpoint-config.yaml
        └── 99-ipsec-master-endpoint-config.yaml
```

7. In your **SiteConfig** CR, add the **custom-manifest/** directory to the **extraManifests.searchPaths** field. For example:

```
clusters:
- clusterName: "site1-sno-du"
  networkType: "OVNKubernetes"
  extraManifests:
    searchPaths:
      - extra-manifest/
      - custom-manifest/
```

8. Commit the **SiteConfig** CR changes and updated files in your Git repository and push the changes to provision the managed cluster and configure IPsec encryption.
   The Argo CD pipeline detects the changes and begins the managed cluster deployment.

   During cluster provisioning, the GitOps ZTP pipeline appends the CRs in the **/custom-manifest** directory to the default set of extra manifests stored in **extra-manifest/**.

Verification

To verify that the IPsec encryption is successfully applied in the managed single-node OpenShift cluster, perform the following steps:

1. Start a debug pod for the managed cluster by running the following command:

```
$ oc debug node/<node_name>
```

2. Check that the IPsec policy is applied in the cluster node:

```
sh-5.1# ip xfrm policy
```

Example output

```
src 172.16.123.0/24 dst 10.1.232.10/32
  dir out priority 1757377 ptype main
  tmpl src 10.1.28.190 dst 10.1.232.10
    proto esp reqid 16393 mode tunnel
src 10.1.232.10/32 dst 172.16.123.0/24
  dir fwd priority 1757377 ptype main
  tmpl src 10.1.232.10 dst 10.1.28.190
    proto esp reqid 16393 mode tunnel
src 10.1.232.10/32 dst 172.16.123.0/24
  dir in priority 1757377 ptype main
  tmpl src 10.1.232.10 dst 10.1.28.190
    proto esp reqid 16393 mode tunnel
```

3. Check that the IPsec tunnel is up and connected:

```
sh-5.1# ip xfrm state
```

Example output

```
src 10.1.232.10 dst 10.1.28.190
  proto esp spi 0xa62a05aa reqid 16393 mode tunnel
  replay-window 0 flag af-unspec esn
  auth-trunc hmac(sha1) 0x8c59f680c8ea1e667b665d8424e2ab749cec12dc 96
  enc cbc(aes)
0x2818a489fe84929c8ab72907e9ce2f0eac6f16f2258bd22240f4087e0326badb
  anti-replay esn context:
   seq-hi 0x0, seq 0x0, oseq-hi 0x0, oseq 0x0
   replay_window 128, bitmap-length 4
   00000000 00000000 00000000 00000000
src 10.1.28.190 dst 10.1.232.10
  proto esp spi 0x8e96e9f9 reqid 16393 mode tunnel
  replay-window 0 flag af-unspec esn
  auth-trunc hmac(sha1) 0xd960ddc0a6baaccb343396a51295e08cfd8aaddd 96
  enc cbc(aes)
0x0273c02e05b4216d5e652de3fc9b3528fea94648bc2b88fa01139fdf0beb27ab
  anti-replay esn context:
   seq-hi 0x0, seq 0x0, oseq-hi 0x0, oseq 0x0
   replay_window 128, bitmap-length 4
   00000000 00000000 00000000 00000000
```

4. Ping a known IP in the external host subnet. For example, ping an IP in the **rightsubnet** range that you set in **ipsec/ipsec-endpoint-config.yaml**:

```
sh-5.1# ping 172.16.110.8
```

Example output

```
sh-5.1# ping 172.16.110.8
PING 172.16.110.8 (172.16.110.8) 56(84) bytes of data.
64 bytes from 172.16.110.8: icmp_seq=1 ttl=64 time=153 ms
64 bytes from 172.16.110.8: icmp_seq=2 ttl=64 time=155 ms
```

Additional resources

- Configuring IPsec encryption
- Encryption protocol and IPsec mode
- Installing managed clusters with RHACM and SiteConfig resources

4.5.3. Single-node OpenShift SiteConfig CR installation reference

Table 4.1. SiteConfig CR installation options for single-node OpenShift clusters

SiteConfig CR field	Description
spec.cpuPartitioningMode	Configure workload partitioning by setting the value for **cpuPartitioningMode** to **AllNodes**. To complete the configuration, specify the**isolated** and **reserved** CPUs in the **PerformanceProfile** CR. NOTE Configuring workload partitioning by using the **cpuPartitioningMode** field in the **SiteConfig** CR is a Tech Preview feature in OpenShift Container Platform 4.13.
metadata.name	Set **name** to **assisted-deployment-pull-secret** and create the **assisted-deployment-pull-secret** CR in the same namespace as the **SiteConfig** CR.
spec.clusterImageSetNameRef	Configure the image set available on the hub cluster for all the clusters in the site. To see the list of supported versions on your hub cluster, run **oc get clusterimagesets**.

SiteConfig CR field	Description
installConfigOverrides	Set the **installConfigOverrides** field to enable or disable optional components prior to cluster installation. IMPORTANT Use the reference configuration as specified in the example **SiteConfig** CR. Adding additional components back into the system might require additional reserved CPU capacity.
spec.clusters.clusterImageSetNameRef	Specifies the cluster image set used to deploy an individual cluster. If defined, it overrides the **spec.clusterImageSetNameRef** at site level.
spec.clusters.clusterLabels	Configure cluster labels to correspond to the binding rules in the **PolicyGenerator** or **PolicyGentemplate** CRs that you define. **PolicyGenerator** CRs use the **policyDefaults.placement.labelSelector** field. **PolicyGentemplate** CRs use the **spec.bindingRules** field. For example, **acmpolicygenerator/acm-common-ranGen.yaml** applies to all clusters with **common: true** set, **acmpolicygenerator/acm-group-du-sno-ranGen.yaml** applies to all clusters with**group-du-sno: ""** set.
spec.clusters.crTemplates.KlusterletAddonConfig	Optional. Set **KlusterletAddonConfig** to **KlusterletAddonConfigOverride.yaml to override the default `KlusterletAddonConfig** that is created for the cluster.
spec.clusters.nodes.hostName	For single-node deployments, define a single host. For three-node deployments, define three hosts. For standard deployments, define three hosts with **role: master** and two or more hosts defined with**role: worker**.
spec.clusters.nodes.nodeLabels	Specify custom roles for your nodes in your managed clusters. These are additional roles are not used by any OpenShift Container Platform components, only by the user. When you add a custom role, it can be associated with a custom machine config pool that references a specific configuration for that role. Adding custom labels or roles during installation makes the deployment process more effective and prevents the need for additional reboots after the installation is complete.
spec.clusters.nodes.automatedCleaningMode	Optional. Uncomment and set the value to **metadata** to enable the removal of the disk's partitioning table only, without fully wiping the disk. The default value is **disabled**.
spec.clusters.nodes.bmcAddress	BMC address that you use to access the host. Applies to all cluster types. GitOps ZTP supports iPXE and virtual media booting by using Redfish or IPMI protocols. To use iPXE booting, you must use RHACM 2.8 or later. For more information about BMC addressing, see the "Additional resources" section.

SiteConfig CR field	Description
spec.clusters.nodes.bmcAddress	BMC address that you use to access the host. Applies to all cluster types. GitOps ZTP supports iPXE and virtual media booting by using Redfish or IPMI protocols. To use iPXE booting, you must use RHACM 2.8 or later. For more information about BMC addressing, see the "Additional resources" section. NOTE In far edge Telco use cases, only virtual media is supported for use with GitOps ZTP.
spec.clusters.nodes.bmcCredentialsName	Configure the **bmh-secret** CR that you separately create with the host BMC credentials. When creating the **bmh-secret** CR, use the same namespace as the **SiteConfig** CR that provisions the host.
spec.clusters.nodes.bootMode	Set the boot mode for the host to **UEFI**. The default value is **UEFI**. Use **UEFISecureBoot** to enable secure boot on the host.
spec.clusters.nodes.rootDeviceHints	Specifies the device for deployment. Identifiers that are stable across reboots are recommended. For example, **wwn: <disk_wwn>** or **deviceName: /dev/disk/by-path/<device_path>**. **<by-path>** values are preferred. For a detailed list of stable identifiers, see the "About root device hints" section.
spec.clusters.nodes.ignitionConfigOverride	Optional. Use this field to assign partitions for persistent storage. Adjust disk ID and size to the specific hardware.
spec.clusters.nodes.nodeNetwork	Configure the network settings for the node.
spec.clusters.nodes.nodeNetwork.config.interfaces.ipv6	Configure the IPv6 address for the host. For single-node OpenShift clusters with static IP addresses, the node-specific API and Ingress IPs should be the same.

Additional resources

- Customizing extra installation manifests in the GitOps ZTP pipeline
- Preparing the GitOps ZTP site configuration repository
- Configuring the hub cluster with ArgoCD
- Signalling GitOps ZTP cluster deployment completion with validator inform policies
- Creating the managed bare-metal host secrets
- BMC addressing

- About root device hints

4.6. MONITORING MANAGED CLUSTER INSTALLATION PROGRESS

The ArgoCD pipeline uses the **SiteConfig** CR to generate the cluster configuration CRs and syncs it with the hub cluster. You can monitor the progress of the synchronization in the ArgoCD dashboard.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

When the synchronization is complete, the installation generally proceeds as follows:

1. The Assisted Service Operator installs OpenShift Container Platform on the cluster. You can monitor the progress of cluster installation from the RHACM dashboard or from the command line by running the following commands:

   a. Export the cluster name:

   ```
   $ export CLUSTER=<clusterName>
   ```

   b. Query the **AgentClusterInstall** CR for the managed cluster:

   ```
   $ oc get agentclusterinstall -n $CLUSTER $CLUSTER -o jsonpath='{.status.conditions[?
   (@.type=="Completed")]}' | jq
   ```

   c. Get the installation events for the cluster:

   ```
   $ curl -sk $(oc get agentclusterinstall -n $CLUSTER $CLUSTER -o
   jsonpath='{.status.debugInfo.eventsURL}')  | jq '.[-2,-1]'
   ```

4.7. TROUBLESHOOTING GITOPS ZTP BY VALIDATING THE INSTALLATION CRS

The ArgoCD pipeline uses the **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** custom resources (CRs) to generate the cluster configuration CRs and Red Hat Advanced Cluster Management (RHACM) policies. Use the following steps to troubleshoot issues that might occur during this process.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Check that the installation CRs were created by using the following command:

   ```
   $ oc get AgentClusterInstall -n <cluster_name>
   ```

If no object is returned, use the following steps to troubleshoot the ArgoCD pipeline flow from **SiteConfig** files to the installation CRs.

2. Verify that the **ManagedCluster** CR was generated using the **SiteConfig** CR on the hub cluster:

   ```
   $ oc get managedcluster
   ```

3. If the **ManagedCluster** is missing, check if the **clusters** application failed to synchronize the files from the Git repository to the hub cluster:

   ```
   $ oc describe -n openshift-gitops application clusters
   ```

   a. Check for the **Status.Conditions** field to view the error logs for the managed cluster. For example, setting an invalid value for **extraManifestPath:** in the **SiteConfig** CR raises the following error:

   ```
   Status:
     Conditions:
       Last Transition Time:  2021-11-26T17:21:39Z
       Message:               rpc error: code = Unknown desc = `kustomize build
   /tmp/https___git.com/ran-sites/siteconfigs/ --enable-alpha-plugins` failed exit status 1:
   2021/11/26 17:21:40 Error could not create extra-manifest ranSite1.extra-manifest3 stat
   extra-manifest3: no such file or directory 2021/11/26 17:21:40 Error: could not build the
   entire SiteConfig defined by /tmp/kust-plugin-config-913473579: stat extra-manifest3: no
   such file or directory Error: failure in plugin configured via /tmp/kust-plugin-config-
   913473579; exit status 1: exit status 1
       Type:  ComparisonError
   ```

   b. Check the **Status.Sync** field. If there are log errors, the **Status.Sync** field could indicate an **Unknown** error:

   ```
   Status:
     Sync:
       Compared To:
         Destination:
           Namespace:  clusters-sub
           Server:     https://kubernetes.default.svc
         Source:
           Path:             sites-config
           Repo URL:         https://git.com/ran-sites/siteconfigs/.git
           Target Revision:  master
       Status:               Unknown
   ```

4.8. TROUBLESHOOTING GITOPS ZTP VIRTUAL MEDIA BOOTING ON SUPERMICRO SERVERS

SuperMicro X11 servers do not support virtual media installations when the image is served using the **https** protocol. As a result, single-node OpenShift deployments for this environment fail to boot on the target node. To avoid this issue, log in to the hub cluster and disable Transport Layer Security (TLS) in the **Provisioning** resource. This ensures the image is not served with TLS even though the image address uses the **https** scheme.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Disable TLS in the **Provisioning** resource by running the following command:

```
$ oc patch provisioning provisioning-configuration --type merge -p '{"spec":
{"disableVirtualMediaTLS": true}}'
```

2. Continue the steps to deploy your single-node OpenShift cluster.

4.9. REMOVING A MANAGED CLUSTER SITE FROM THE GITOPS ZTP PIPELINE

You can remove a managed site and the associated installation and configuration policy CRs from the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Remove a site and the associated CRs by removing the associated **SiteConfig** and **PolicyGenerator** or **PolicyGentemplate** files from the **kustomization.yaml** file.
   When you run the GitOps ZTP pipeline again, the generated CRs are removed.
2. Optional: If you want to permanently remove a site, you should also remove the **SiteConfig** and site-specific **PolicyGenerator** or **PolicyGentemplate** files from the Git repository.
3. Optional: If you want to remove a site temporarily, for example when redeploying a site, you can leave the **SiteConfig** and site-specific **PolicyGenerator** or **PolicyGentemplate** CRs in the Git repository.

Additional resources

- For information about removing a cluster, see Removing a cluster from management.

4.10. REMOVING OBSOLETE CONTENT FROM THE GITOPS ZTP PIPELINE

If a change to the **PolicyGenerator** or **PolicyGentemplate** configuration results in obsolete policies, for example, if you rename policies, use the following procedure to remove the obsolete policies.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Remove the affected **PolicyGenerator** or **PolicyGentemplate** files from the Git repository, commit and push to the remote repository.

2. Wait for the changes to synchronize through the application and the affected policies to be removed from the hub cluster.

3. Add the updated **PolicyGenerator** or **PolicyGentemplate** files back to the Git repository, and then commit and push to the remote repository.

   NOTE

   Removing GitOps Zero Touch Provisioning (ZTP) policies from the Git repository, and as a result also removing them from the hub cluster, does not affect the configuration of the managed cluster. The policy and CRs managed by that policy remains in place on the managed cluster.

4. Optional: As an alternative, after making changes to **PolicyGenerator** or **PolicyGentemplate** CRs that result in obsolete policies, you can remove these policies from the hub cluster manually. You can delete policies from the RHACM console using the **Governance** tab or by running the following command:

```
$ oc delete policy -n <namespace> <policy_name>
```

4.11. TEARING DOWN THE GITOPS ZTP PIPELINE

You can remove the ArgoCD pipeline and all generated GitOps Zero Touch Provisioning (ZTP) artifacts.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Detach all clusters from Red Hat Advanced Cluster Management (RHACM) on the hub cluster.

2. Delete the **kustomization.yaml** file in the **deployment** directory using the following command:

```
$ oc delete -k out/argocd/deployment
```

3. Commit and push your changes to the site repository.

CHAPTER 5. MANUALLY INSTALLING A SINGLE-NODE OPENSHIFT CLUSTER WITH GITOPS ZTP

You can deploy a managed single-node OpenShift cluster by using Red Hat Advanced Cluster Management (RHACM) and the assisted service.

NOTE

If you are creating multiple managed clusters, use the **SiteConfig** method described in Deploying far edge sites with ZTP .

IMPORTANT

The target bare-metal host must meet the networking, firmware, and hardware requirements listed in Recommended cluster configuration for vDU application workloads.

5.1. GENERATING GITOPS ZTP INSTALLATION AND CONFIGURATION CRS MANUALLY

Use the **generator** entrypoint for the **ztp-site-generate** container to generate the site installation and configuration custom resource (CRs) for a cluster based on **SiteConfig** and **PolicyGenerator** CRs.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. Create an output folder by running the following command:

```
$ mkdir -p ./out
```

2. Export the **argocd** directory from the **ztp-site-generate** container image:

```
$ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16 extract /home/ztp --tar | tar x -C ./out
```

The **./out** directory has the reference **PolicyGenerator** and **SiteConfig** CRs in the **out/argocd/example/** folder.

Example output

```
out
 └── argocd
      └── example
           ├── acmpolicygenerator
           │    ├── {policy-prefix}common-ranGen.yaml
           │    ├── {policy-prefix}example-sno-site.yaml
           │    ├── {policy-prefix}group-du-sno-ranGen.yaml
      │    ├── {policy-prefix}group-du-sno-validator-ranGen.yaml
      │    ├── ...
      │    ├── kustomization.yaml
      │    └── ns.yaml
      └── siteconfig
           ├── example-sno.yaml
           ├── KlusterletAddonConfigOverride.yaml
           └── kustomization.yaml
```

3. Create an output folder for the site installation CRs:

```
$ mkdir -p ./site-install
```

4. Modify the example **SiteConfig** CR for the cluster type that you want to install. Copy **example-sno.yaml** to **site-1-sno.yaml** and modify the CR to match the details of the site and bare-metal host that you want to install, for example:

```
# example-node1-bmh-secret & assisted-deployment-pull-secret need to be created under
same namespace example-sno
---
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "example-sno"
  namespace: "example-sno"
spec:
  baseDomain: "example.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
  clusterImageSetNameRef: "openshift-4.10"
  sshPublicKey: "ssh-rsa AAAA..."
  clusters:
  - clusterName: "example-sno"
    networkType: "OVNKubernetes"
    # installConfigOverrides is a generic way of passing install-config
    # parameters through the siteConfig.  The 'capabilities' field configures
    # the composable openshift feature.  In this 'capabilities' setting, we
    # remove all but the marketplace component from the optional set of
    # components.
    # Notes:
    # - OperatorLifecycleManager is needed for 4.15 and later
    # - NodeTuning is needed for 4.13 and later, not for 4.12 and earlier
    # - Ingress is needed for 4.16 and later
    installConfigOverrides: |
      {
        "capabilities": {
          "baselineCapabilitySet": "None",
          "additionalEnabledCapabilities": [
            "NodeTuning",
            "OperatorLifecycleManager"
            "Ingress"
          ]
        }
      }
    # It is strongly recommended to include crun manifests as part of the additional install-time
```

```
manifests for 4.13+.
  # The crun manifests can be obtained from source-crs/optional-extra-manifest/ and added
to the git repo ie.sno-extra-manifest.
  # extraManifestPath: sno-extra-manifest
  clusterLabels:
    # These example cluster labels correspond to the bindingRules in the
PolicyGenTemplate examples
    du-profile: "latest"
    # These example cluster labels correspond to the bindingRules in the
PolicyGenTemplate examples in ../policygentemplates:
    # ../policygentemplates/common-ranGen.yaml will apply to all clusters with 'common: true'
    common: true
    # ../policygentemplates/group-du-sno-ranGen.yaml will apply to all clusters with 'group-
du-sno: ""'
    group-du-sno: ""
    # ../policygentemplates/example-sno-site.yaml will apply to all clusters with 'sites:
"example-sno"'
    # Normally this should match or contain the cluster name so it only applies to a single
cluster
    sites : "example-sno"
  clusterNetwork:
   - cidr: 1001:1::/48
     hostPrefix: 64
  machineNetwork:
   - cidr: 1111:2222:3333:4444::/64
  serviceNetwork:
   - 1001:2::/112
  additionalNTPSources:
   - 1111:2222:3333:4444::2
  # Initiates the cluster for workload partitioning. Setting specific reserved/isolated CPUSets
is done via PolicyTemplate
  # please see Workload Partitioning Feature for a complete guide.
  cpuPartitioningMode: AllNodes
  # Optionally; This can be used to override the KlusterletAddonConfig that is created for this
cluster:
  #crTemplates:
  #  KlusterletAddonConfig: "KlusterletAddonConfigOverride.yaml"
  nodes:
   - hostName: "example-node1.example.com"
     role: "master"
     # Optionally; This can be used to configure desired BIOS setting on a host:
     #biosConfigRef:
     #  filePath: "example-hw.profile"
     bmcAddress: "idrac-
virtualmedia+https://[1111:2222:3333:4444::bbbb:1]/redfish/v1/Systems/System.Embedded.1"

     bmcCredentialsName:
       name: "example-node1-bmh-secret"
     bootMACAddress: "AA:BB:CC:DD:EE:11"
     # Use UEFISecureBoot to enable secure boot
     bootMode: "UEFI"
     rootDeviceHints:
       deviceName: "/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0"
     # disk partition at `/var/lib/containers` with ignitionConfigOverride. Some values must be
updated. See DiskPartitionContainer.md for more details
     ignitionConfigOverride: |
        {
         "ignition": {
           "version": "3.2.0"
         },
         "storage": {
           "disks": [
             {
               "device": "/dev/disk/by-id/wwn-0x6b07b250ebb9d0002a33509f24af1f62",
               "partitions": [
                 {
                  "label": "var-lib-containers",
                  "sizeMiB": 0,
                  "startMiB": 250000
                 }
               ],
               "wipeTable": false
             }
           ],
         "filesystems": [
           {
            "device": "/dev/disk/by-partlabel/var-lib-containers",
            "format": "xfs",
            "mountOptions": [
              "defaults",
              "prjquota"
             ],
             "path": "/var/lib/containers",
             "wipeFilesystem": true
            }
          ]
        },
        "systemd": {
          "units": [
            {
             "contents": "# Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-fs.target",
             "enabled": true,
             "name": "var-lib-containers.mount"
            }
          ]
         }
        }
      nodeNetwork:
        interfaces:
          - name: eno1
            macAddress: "AA:BB:CC:DD:EE:11"
        config:
          interfaces:
            - name: eno1
              type: ethernet
              state: up
              ipv4:
```

```
        enabled: false
      ipv6:
        enabled: true
        address:
        # For SNO sites with static IP addresses, the node-specific,
        # API and Ingress IPs should all be the same and configured on
        # the interface
        - ip: 1111:2222:3333:4444::aaaa:1
          prefix-length: 64
  dns-resolver:
    config:
      search:
      - example.com
      server:
      - 1111:2222:3333:4444::2
  routes:
    config:
    - destination: ::/0
      next-hop-interface: eno1
      next-hop-address: 1111:2222:3333:4444::1
      table-id: 254
```

NOTE

Once you have extracted reference CR configuration files from the **out/extra-manifest** directory of the **ztp-site-generate** container, you can use **extraManifests.searchPaths** to include the path to the git directory containing those files. This allows the GitOps ZTP pipeline to apply those CR files during cluster installation. If you configure a **searchPaths** directory, the GitOps ZTP pipeline does not fetch manifests from the **ztp-site-generate** container during site installation.

5. Generate the Day 0 installation CRs by processing the modified **SiteConfig** CR **site-1-sno.yaml** by running the following command:

```
$ podman run -it --rm -v `pwd`/out/argocd/example/siteconfig:/resources:Z -v `pwd`/site-install:/output:Z,U registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16 generator install site-1-sno.yaml /output
```

Example output

```
site-install
└── site-1-sno
    ├── site-1_agentclusterinstall_example-sno.yaml
    ├── site-1-sno_baremetalhost_example-node1.example.com.yaml
    ├── site-1-sno_clusterdeployment_example-sno.yaml
    ├── site-1-sno_configmap_example-sno.yaml
    ├── site-1-sno_infraenv_example-sno.yaml
    ├── site-1-sno_klusterletaddonconfig_example-sno.yaml
    ├── site-1-sno_machineconfig_02-master-workload-partitioning.yaml
    ├── site-1-sno_machineconfig_predefined-extra-manifests-master.yaml
    ├── site-1-sno_machineconfig_predefined-extra-manifests-worker.yaml
    ├── site-1-sno_managedcluster_example-sno.yaml
    ├── site-1-sno_namespace_example-sno.yaml
    └── site-1-sno_nmstateconfig_example-node1.example.com.yaml
```

6. Optional: Generate just the Day 0 **MachineConfig** installation CRs for a particular cluster type by processing the reference **SiteConfig** CR with the **-E** option. For example, run the following commands:

   a. Create an output folder for the **MachineConfig** CRs:

   ```
   $ mkdir -p ./site-machineconfig
   ```

   b. Generate the **MachineConfig** installation CRs:

   ```
   $ podman run -it --rm -v `pwd`/out/argocd/example/siteconfig:/resources:Z -v `pwd`/site-machineconfig:/output:Z,U registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16 generator install -E site-1-sno.yaml /output
   ```

   Example output

   ```
   site-machineconfig
   └── site-1-sno
       ├── site-1-sno_machineconfig_02-master-workload-partitioning.yaml
       ├── site-1-sno_machineconfig_predefined-extra-manifests-master.yaml
       └── site-1-sno_machineconfig_predefined-extra-manifests-worker.yaml
   ```

7. Generate and export the Day 2 configuration CRs using the reference **PolicyGenerator** CRs from the previous step. Run the following commands:

   a. Create an output folder for the Day 2 CRs:

   ```
   $ mkdir -p ./ref
   ```

   b. Generate and export the Day 2 configuration CRs:

   ```
   $ podman run -it --rm -v `pwd`/out/argocd/example/acmpolicygenerator:/resources:Z -v `pwd`/ref:/output:Z,U registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16 generator config -N . /output
   ```

   The command generates example group and site-specific **PolicyGenerator** CRs for single-node OpenShift, three-node clusters, and standard clusters in the **./ref** folder.

   Example output

   ```
   ref
    └── customResource
        ├── common
        ├── example-multinode-site
        ├── example-sno
        ├── group-du-3node
        ├── group-du-3node-validator
        │   └── Multiple-validatorCRs
        ├── group-du-sno
        ├── group-du-sno-validator
   ```

```
        ├── group-du-standard
        └── group-du-standard-validator
            └── Multiple-validatorCRs
```

8. Use the generated CRs as the basis for the CRs that you use to install the cluster. You apply the installation CRs to the hub cluster as described in "Installing a single managed cluster". The configuration CRs can be applied to the cluster after cluster installation is complete.

Verification

- Verify that the custom roles and labels are applied after the node is deployed:

```
$ oc describe node example-node.example.com
```

Example output

```
Name:   example-node.example.com
Roles:  control-plane,example-label,master,worker
Labels: beta.kubernetes.io/arch=amd64
        beta.kubernetes.io/os=linux
        custom-label/parameter1=true
        kubernetes.io/arch=amd64
        kubernetes.io/hostname=cnfdf03.telco5gran.eng.rdu2.redhat.com
        kubernetes.io/os=linux
        node-role.kubernetes.io/control-plane=
        node-role.kubernetes.io/example-label= 1
        node-role.kubernetes.io/master=
        node-role.kubernetes.io/worker=
        node.openshift.io/os_id=rhcos
```

1 The custom label is applied to the node.

Additional resources

- Workload partitioning
- BMC addressing
- About root device hints
- Single-node OpenShift SiteConfig CR installation reference

5.2. CREATING THE MANAGED BARE-METAL HOST SECRETS

Add the required **Secret** custom resources (CRs) for the managed bare-metal host to the hub cluster. You need a secret for the GitOps Zero Touch Provisioning (ZTP) pipeline to access the Baseboard Management Controller (BMC) and a secret for the assisted installer service to pull cluster installation images from the registry.

NOTE

The secrets are referenced from the **SiteConfig** CR by name. The namespace must match the **SiteConfig** namespace.

Procedure

1. Create a YAML secret file containing credentials for the host Baseboard Management Controller (BMC) and a pull secret required for installing OpenShift and all add-on cluster Operators:

   a. Save the following YAML as the file **example-sno-secret.yaml**:

```
apiVersion: v1
kind: Secret
metadata:
  name: example-sno-bmc-secret
  namespace: example-sno (1)
data: (2)
  password: <base64_password>
  username: <base64_username>
type: Opaque
---
apiVersion: v1
kind: Secret
metadata:
  name: pull-secret
  namespace: example-sno (3)
data:
  .dockerconfigjson: <pull_secret> (4)
type: kubernetes.io/dockerconfigjson
```

(1) Must match the namespace configured in the related **SiteConfig** CR

(2) Base64-encoded values for **password** and **username**

(3) Must match the namespace configured in the related **SiteConfig** CR

(4) Base64-encoded pull secret

2. Add the relative path to **example-sno-secret.yaml** to the **kustomization.yaml** file that you use to install the cluster.

5.3. CONFIGURING DISCOVERY ISO KERNEL ARGUMENTS FOR MANUAL INSTALLATIONS USING GITOPS ZTP

The GitOps Zero Touch Provisioning (ZTP) workflow uses the Discovery ISO as part of the OpenShift Container Platform installation process on managed bare-metal hosts. You can edit the **InfraEnv** resource to specify kernel arguments for the Discovery ISO. This is useful for cluster installations with specific environmental requirements. For example, configure the **rd.net.timeout.carrier** kernel argument for the Discovery ISO to facilitate static networking for the cluster or to receive a DHCP address before downloading the root file system during installation.

NOTE

In OpenShift Container Platform 4.16, you can only add kernel arguments. You can not replace or delete kernel arguments.

Prerequisites

- You have installed the OpenShift CLI (oc).
- You have logged in to the hub cluster as a user with cluster-admin privileges.
- You have manually generated the installation and configuration custom resources (CRs).

Procedure

1. Edit the **spec.kernelArguments** specification in the **InfraEnv** CR to configure kernel arguments:

```
apiVersion: agent-install.openshift.io/v1beta1
kind: InfraEnv
metadata:
  name: <cluster_name>
  namespace: <cluster_name>
spec:
  kernelArguments:
    - operation: append (1)
      value: audit=0 (2)
    - operation: append
      value: trace=1
  clusterRef:
    name: <cluster_name>
    namespace: <cluster_name>
  pullSecretRef:
    name: pull-secret
```

(1) Specify the append operation to add a kernel argument.

(2) Specify the kernel argument you want to configure. This example configures the audit kernel argument and the trace kernel argument.

NOTE

The **SiteConfig** CR generates the **InfraEnv** resource as part of the day-0 installation CRs.

Verification

To verify that the kernel arguments are applied, after the Discovery image verifies that OpenShift Container Platform is ready for installation, you can SSH to the target host before the installation process begins. At that point, you can view the kernel arguments for the Discovery ISO in the **/proc/cmdline** file.

1. Begin an SSH session with the target host:

```
$ ssh -i /path/to/privatekey core@<host_name>
```

2. View the system's kernel arguments by using the following command:

```
$ cat /proc/cmdline
```

–

5.4. INSTALLING A SINGLE MANAGED CLUSTER

You can manually deploy a single managed cluster using the assisted service and Red Hat Advanced Cluster Management (RHACM).

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created the baseboard management controller (BMC) **Secret** and the image pull-secret **Secret** custom resources (CRs). See "Creating the managed bare-metal host secrets" for details.
- Your target bare-metal host meets the networking and hardware requirements for managed clusters.

Procedure

1. Create a **ClusterImageSet** for each specific cluster version to be deployed, for example **clusterImageSet-4.16.yaml**. A **ClusterImageSet** has the following format:

```
apiVersion: hive.openshift.io/v1
kind: ClusterImageSet
metadata:
  name: openshift-4.16.0 (1)
spec:
   releaseImage: quay.io/openshift-release-dev/ocp-release:4.16.0-x86_64 (2)
```

(1) The descriptive version that you want to deploy.

(2) Specifies the **releaseImage** to deploy and determines the operating system image version. The discovery ISO is based on the image version as set by **releaseImage**, or the latest version if the exact version is unavailable.

2. Apply the **clusterImageSet** CR:

```
$ oc apply -f clusterImageSet-4.16.yaml
```

3. Create the **Namespace** CR in the **cluster-namespace.yaml** file:

```
apiVersion: v1
kind: Namespace
metadata:
     name: <cluster_name> (1)
     labels:
        name: <cluster_name> (2)
```

(1) (2) The name of the managed cluster to provision.

4. Apply the **Namespace** CR by running the following command:

```
$ oc apply -f cluster-namespace.yaml
```

5. Apply the generated day-0 CRs that you extracted from the **ztp-site-generate** container and customized to meet your requirements:

```
$ oc apply -R ./site-install/site-sno-1
```

Additional resources

- Connectivity prerequisites for managed cluster networks
- Deploying LVM Storage on single-node OpenShift clusters
- Configuring LVM Storage using PolicyGenerator CRs

5.5. MONITORING THE MANAGED CLUSTER INSTALLATION STATUS

Ensure that cluster provisioning was successful by checking the cluster status.

Prerequisites

- All of the custom resources have been configured and provisioned, and the **Agent** custom resource is created on the hub for the managed cluster.

Procedure

1. Check the status of the managed cluster:

```
$ oc get managedcluster
```

True indicates the managed cluster is ready.

2. Check the agent status:

```
$ oc get agent -n <cluster_name>
```

3. Use the **describe** command to provide an in-depth description of the agent's condition. Statuses to be aware of include **BackendError**, **InputError**, **ValidationsFailing**, **InstallationFailed**, and **AgentIsConnected**. These statuses are relevant to the **Agent** and **AgentClusterInstall** custom resources.

```
$ oc describe agent -n <cluster_name>
```

4. Check the cluster provisioning status:

```
$ oc get agentclusterinstall -n <cluster_name>
```

5. Use the **describe** command to provide an in-depth description of the cluster provisioning status:

```
$ oc describe agentclusterinstall -n <cluster_name>
```

6. Check the status of the managed cluster’s add-on services:

```
$ oc get managedclusteraddon -n <cluster_name>
```

7. Retrieve the authentication information of the **kubeconfig** file for the managed cluster:

```
$ oc get secret -n <cluster_name> <cluster_name>-admin-kubeconfig -o jsonpath=
{.data.kubeconfig} | base64 -d > <directory>/<cluster_name>-kubeconfig
```

5.6. TROUBLESHOOTING THE MANAGED CLUSTER

Use this procedure to diagnose any installation issues that might occur with the managed cluster.

Procedure

1. Check the status of the managed cluster:

```
$ oc get managedcluster
```

Example output

```
NAME            HUB ACCEPTED   MANAGED CLUSTER URLS   JOINED   AVAILABLE
AGE
SNO-cluster     true                                  True     True      2d19h
```

If the status in the **AVAILABLE** column is **True**, the managed cluster is being managed by the hub.

If the status in the **AVAILABLE** column is **Unknown**, the managed cluster is not being managed by the hub. Use the following steps to continue checking to get more information.

2. Check the **AgentClusterInstall** install status:

```
$ oc get clusterdeployment -n <cluster_name>
```

Example output

```
NAME        PLATFORM          REGION   CLUSTERTYPE   INSTALLED    INFRAID
VERSION  POWERSTATE AGE
Sno0026     agent-baremetal                          false                    Initialized
2d14h
```

If the status in the **INSTALLED** column is **false**, the installation was unsuccessful.

3. If the installation failed, enter the following command to review the status of the **AgentClusterInstall** resource:

```
$ oc describe agentclusterinstall -n <cluster_name> <cluster_name>
```

4. Resolve the errors and reset the cluster:

   a. Remove the cluster’s managed cluster resource:

   ```
   $ oc delete managedcluster <cluster_name>
   ```

   b. Remove the cluster’s namespace:

   ```
   $ oc delete namespace <cluster_name>
   ```

   This deletes all of the namespace-scoped custom resources created for this cluster. You must wait for the **ManagedCluster** CR deletion to complete before proceeding.

   c. Recreate the custom resources for the managed cluster.

5.7. RHACM GENERATED CLUSTER INSTALLATION CRS REFERENCE

Red Hat Advanced Cluster Management (RHACM) supports deploying OpenShift Container Platform on single-node clusters, three-node clusters, and standard clusters with a specific set of installation custom resources (CRs) that you generate using **SiteConfig** CRs for each site.

NOTE

Every managed cluster has its own namespace, and all of the installation CRs except for **ManagedCluster** and **ClusterImageSet** are under that namespace. **ManagedCluster** and **ClusterImageSet** are cluster-scoped, not namespace-scoped. The namespace and the CR names match the cluster name.

The following table lists the installation CRs that are automatically applied by the RHACM assisted service when it installs clusters using the **SiteConfig** CRs that you configure.

Table 5.1. Cluster installation CRs generated by RHACM

CR	Description	Usage
BareMetalHost	Contains the connection information for the Baseboard Management Controller (BMC) of the target bare-metal host.	Provides access to the BMC to load and start the discovery image on the target server by using the Redfish protocol.
InfraEnv	Contains information for installing OpenShift Container Platform on the target bare-metal host.	Used with **ClusterDeployment** to generate the discovery ISO for the managed cluster.
AgentClusterInstall	Specifies details of the managed cluster configuration such as networking and the number of control plane nodes. Displays the cluster **kubeconfig** and credentials when the installation is complete.	Specifies the managed cluster configuration information and provides status during the installation of the cluster.
ClusterDeployment	References the **AgentClusterInstall** CR to use.	Used with **InfraEnv** to generate the discovery ISO for the managed cluster.

CR	Description	Usage
NMStateConfig	Provides network configuration information such as **MAC** address to **IP** mapping, DNS server, default route, and other network settings.	Sets up a static IP address for the managed cluster’s Kube API server.
Agent	Contains hardware information about the target bare-metal host.	Created automatically on the hub when the target machine’s discovery image boots.
ManagedCluster	When a cluster is managed by the hub, it must be imported and known. This Kubernetes object provides that interface.	The hub uses this resource to manage and show the status of managed clusters.
KlusterletAddonConfig	Contains the list of services provided by the hub to be deployed to the **ManagedCluster** resource.	Tells the hub which addon services to deploy to the **ManagedCluster** resource.
Namespace	Logical space for **ManagedCluster** resources existing on the hub. Unique per site.	Propagates resources to the **ManagedCluster**.
Secret	Two CRs are created: **BMC Secret** and **Image Pull Secret**.	• **BMC Secret** authenticates into the target bare-metal host using its username and password. • **Image Pull Secret** contains authentication information for the OpenShift Container Platform image installed on the target bare-metal host.
ClusterImageSet	Contains OpenShift Container Platform image information such as the repository and image name.	Passed into resources to provide OpenShift Container Platform images.

CHAPTER 6. RECOMMENDED SINGLE-NODE OPENSHIFT CLUSTER CONFIGURATION FOR VDU APPLICATION WORKLOADS

Use the following reference information to understand the single-node OpenShift configurations required to deploy virtual distributed unit (vDU) applications in the cluster. Configurations include cluster optimizations for high performance workloads, enabling workload partitioning, and minimizing the number of reboots required postinstallation.

Additional resources

- To deploy a single cluster by hand, see Manually installing a single-node OpenShift cluster with GitOps ZTP.
- To deploy a fleet of clusters using GitOps Zero Touch Provisioning (ZTP), see Deploying far edge sites with GitOps ZTP.

6.1. RUNNING LOW LATENCY APPLICATIONS ON OPENSHIFT CONTAINER PLATFORM

OpenShift Container Platform enables low latency processing for applications running on commercial off-the-shelf (COTS) hardware by using several technologies and specialized hardware devices:

Real-time kernel for RHCOS

Ensures workloads are handled with a high degree of process determinism.

CPU isolation

Avoids CPU scheduling delays and ensures CPU capacity is available consistently.

NUMA-aware topology management

Aligns memory and huge pages with CPU and PCI devices to pin guaranteed container memory and huge pages to the non-uniform memory access (NUMA) node. Pod resources for all Quality of Service (QoS) classes stay on the same NUMA node. This decreases latency and improves performance of the node.

Huge pages memory management

Using huge page sizes improves system performance by reducing the amount of system resources required to access page tables.

Precision timing synchronization using PTP

Allows synchronization between nodes in the network with sub-microsecond accuracy.

6.2. RECOMMENDED CLUSTER HOST REQUIREMENTS FOR VDU APPLICATION WORKLOADS

Running vDU application workloads requires a bare-metal host with sufficient resources to run OpenShift Container Platform services and production workloads.

Table 6.1. Minimum resource requirements

Profile	vCPU	Memory	Storage
Minimum	4 to 8 vCPU cores	32GB of RAM	120GB

NOTE

One vCPU is equivalent to one physical core when simultaneous multithreading (SMT), or Hyper-Threading, is not enabled. When enabled, use the following formula to calculate the corresponding ratio:

- (threads per core × cores) × sockets = vCPUs

IMPORTANT

The server must have a Baseboard Management Controller (BMC) when booting with virtual media.

6.3. CONFIGURING HOST FIRMWARE FOR LOW LATENCY AND HIGH PERFORMANCE

Bare-metal hosts require the firmware to be configured before the host can be provisioned. The firmware configuration is dependent on the specific hardware and the particular requirements of your installation.

Procedure

1. Set the **UEFI/BIOS Boot Mode** to **UEFI**.
2. In the host boot sequence order, set **Hard drive first**
3. Apply the specific firmware configuration for your hardware. The following table describes a representative firmware configuration for an Intel Xeon Skylake server and later hardware generations, based on the Intel FlexRAN 4G and 5G baseband PHY reference design.

   IMPORTANT

   The exact firmware configuration depends on your specific hardware and network requirements. The following sample configuration is for illustrative purposes only.

   Table 6.2. Sample firmware configuration

Firmware setting	Configuration
CPU Power and Performance Policy	Performance
Uncore Frequency Scaling	Disabled
Performance P-limit	Disabled

Firmware setting	Configuration
Enhanced Intel SpeedStep ® Tech	Enabled
Intel Configurable TDP	Enabled
Configurable TDP Level	Level 2
Intel® Turbo Boost Technology	Enabled
Energy Efficient Turbo	Disabled
Hardware P-States	Disabled
Package C-State	C0/C1 state
C1E	Disabled
Processor C6	Disabled

NOTE

Enable global SR-IOV and VT-d settings in the firmware for the host. These settings are relevant to bare-metal environments.

6.4. CONNECTIVITY PREREQUISITES FOR MANAGED CLUSTER NETWORKS

Before you can install and provision a managed cluster with the GitOps Zero Touch Provisioning (ZTP) pipeline, the managed cluster host must meet the following networking prerequisites:

- There must be bi-directional connectivity between the GitOps ZTP container in the hub cluster and the Baseboard Management Controller (BMC) of the target bare-metal host.
- The managed cluster must be able to resolve and reach the API hostname of the hub hostname and ***.apps** hostname. Here is an example of the API hostname of the hub and ***.apps** hostname:
  - **api.hub-cluster.internal.domain.com**
  - **console-openshift-console.apps.hub-cluster.internal.domain.com**
- The hub cluster must be able to resolve and reach the API and ***.apps** hostname of the managed cluster. Here is an example of the API hostname of the managed cluster and ***.apps** hostname:
  - **api.sno-managed-cluster-1.internal.domain.com**
  - **console-openshift-console.apps.sno-managed-cluster-1.internal.domain.com**

6.5. WORKLOAD PARTITIONING IN SINGLE-NODE OPENSHIFT WITH GITOPS ZTP

Workload partitioning configures OpenShift Container Platform services, cluster management workloads, and infrastructure pods to run on a reserved number of host CPUs.

To configure workload partitioning with GitOps Zero Touch Provisioning (ZTP), you configure a **cpuPartitioningMode** field in the **SiteConfig** custom resource (CR) that you use to install the cluster and you apply a **PerformanceProfile** CR that configures the **isolated** and **reserved** CPUs on the host.

Configuring the **SiteConfig** CR enables workload partitioning at cluster installation time and applying the **PerformanceProfile** CR configures the specific allocation of CPUs to reserved and isolated sets. Both of these steps happen at different points during cluster provisioning.

NOTE

Configuring workload partitioning by using the **cpuPartitioningMode** field in the **SiteConfig** CR is a Tech Preview feature in OpenShift Container Platform 4.13.

Alternatively, you can specify cluster management CPU resources with the **cpuset** field of the **SiteConfig** custom resource (CR) and the **reserved** field of the group **PolicyGenerator** or **PolicyGentemplate** CR. The GitOps ZTP pipeline uses these values to populate the required fields in the workload partitioning **MachineConfig** CR (**cpuset**) and the **PerformanceProfile** CR (**reserved**) that configure the single-node OpenShift cluster. This method is a General Availability feature in OpenShift Container Platform 4.14.

The workload partitioning configuration pins the OpenShift Container Platform infrastructure pods to the **reserved** CPU set. Platform services such as systemd, CRI-O, and kubelet run on the **reserved** CPU set. The **isolated** CPU sets are exclusively allocated to your container workloads. Isolating CPUs ensures that the workload has guaranteed access to the specified CPUs without contention from other applications running on the same node. All CPUs that are not isolated should be reserved.

IMPORTANT

Ensure that **reserved** and **isolated** CPU sets do not overlap with each other.

Additional resources

- For the recommended single-node OpenShift workload partitioning configuration, see Workload partitioning.

6.6. RECOMMENDED CLUSTER INSTALL MANIFESTS

The ZTP pipeline applies the following custom resources (CRs) during cluster installation. These configuration CRs ensure that the cluster meets the feature and performance requirements necessary for running a vDU application.

NOTE

When using the GitOps ZTP plugin and **SiteConfig** CRs for cluster deployment, the following **MachineConfig** CRs are included by default.

Use the **SiteConfig extraManifests** filter to alter the CRs that are included by default. For more information, see Advanced managed cluster configuration with SiteConfig CRs .

6.6.1. Workload partitioning

Single-node OpenShift clusters that run DU workloads require workload partitioning. This limits the cores allowed to run platform services, maximizing the CPU core for application payloads.

NOTE

Workload partitioning can be enabled during cluster installation only. You cannot disable workload partitioning postinstallation. You can however change the set of CPUs assigned to the isolated and reserved sets through the **PerformanceProfile** CR. Changes to CPU settings cause the node to reboot.

UPGRADING FROM OPENSHIFT CONTAINER PLATFORM 4.12 TO 4.13+

When transitioning to using **cpuPartitioningMode** for enabling workload partitioning, remove the workload partitioning **MachineConfig** CRs from the **/extra-manifest** folder that you use to provision the cluster.

Recommended SiteConfig CR configuration for workload partitioning

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "<site_name>"
  namespace: "<site_name>"
spec:
  baseDomain: "example.com"
  cpuPartitioningMode: AllNodes 1
```

1 Set the **cpuPartitioningMode** field to **AllNodes** to configure workload partitioning for all nodes in the cluster.

Verification

Check that the applications and cluster system CPU pinning is correct. Run the following commands:

1. Open a remote shell prompt to the managed cluster:

```
$ oc debug node/example-sno-1
```

2. Check that the OpenShift infrastructure applications CPU pinning is correct:

```
sh-4.4# pgrep ovn | while read i; do taskset -cp $i; done
```

Example output

```
pid 8481's current affinity list: 0-1,52-53
pid 8726's current affinity list: 0-1,52-53
pid 9088's current affinity list: 0-1,52-53
pid 9945's current affinity list: 0-1,52-53
pid 10387's current affinity list: 0-1,52-53
pid 12123's current affinity list: 0-1,52-53
pid 13313's current affinity list: 0-1,52-53
```

3. Check that the system applications CPU pinning is correct:

```
sh-4.4# pgrep systemd | while read i; do taskset -cp $i; done
```

Example output

```
pid 1's current affinity list: 0-1,52-53
pid 938's current affinity list: 0-1,52-53
pid 962's current affinity list: 0-1,52-53
pid 1197's current affinity list: 0-1,52-53
```

6.6.2. Reduced platform management footprint

To reduce the overall management footprint of the platform, a **MachineConfig** custom resource (CR) is required that places all Kubernetes-specific mount points in a new namespace separate from the host operating system. The following base64-encoded example **MachineConfig** CR illustrates this configuration.

Recommended container mount namespace configuration (01-container-mount-ns-and-kubelet-conf-master.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: container-mount-namespace-and-kubelet-conf-master
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,IyEvYmluL2Jhc2gKCmRlYnVnKCkgewogIGVjaG8gJEAgPiYyCn0KCnVzYWdlKCkgewogIGVj
aG8gVXNhZ2U6ICQoYmFzZW5hbWUgJDApIFVOSVQgW2VudmZpbGUgW3Zhcm5hbWVdXQogIGV
jaG8KICBlY2hvIEV4dHJhY3QgdGhlIGNvbnRlbnRzIG9mIHRoZSBmaXJzdCBFeGVjU3RhcnQgc3Rhbn
phIGZyb20gdGhlIGdpdmVuIHN5c3RlbWQgdW5pdCBhbmQgcmV0dXJuIGl0IHRvIHN0ZG91dAogIGVj
aG8KICBlY2hvICJJZiAnZW52ZmlsZScgaXMgcHJvdmlkZWQsIHB1dCBpdCBpbiB0aGVyZSBpbnN0ZW
FkLCBhcyBhbiBlbnZpcm9ubWVudCB2YXJpYWJsZSBuYW1lZCAndmFybmFtZSciCiAgZWNobyAiRGV
mYXVsdCAndmFybmFtZScgaXMgRVhFQ1NUQVJUIGlmIG5vdCBzcGVjaWZpZWQiCiAgZXhpdCAxC
n0KClVOSVQ9JDEKRU5WRklMRT0kMgpWQVJOQU1FPSQzCmlmIFtbIC16ICRVTklUIHx8ICRVTklUI
D09ICItLWhlbHAiIHx8ICRVTklUID09ICItaCIgXV07IHRoZW4KICB1c2FnZQpmaQpkZWJ1ZyAiRXh0cm
FjdGluZyBFeGVjU3RhcnQgZnJvbSAkVU5JVCIKRklMRT0kKHN5c3RlbWN0bCBjYXQgJFVOSVQgfCB
oZWFkIC1uIDEpCkZJTEU9JHtGSUxFI1wjIH0KaWYgW1sgISAtZiAkRklMRSBdXTsgdGhlbgogIGRlYnV
nICJGYWlsZWQgdG8gZmluZCByb290IGZpbGUgZm9yIHVuaXQgJFVOSVQgKCRGSUxFKSIKICBle
Gl0CmZpCmRlYnVnICJTZXJ2aWNlIGRlZmluaXRpb24gaXMgaW4gJEZJTEUiCkVYRUNTVEFSVD0k
KHNlZCAtbiAtZSAnL15FeGVjU3RhcnQ9LipcXCQvLC9bXlxcXSQvIHsgcy9eRXhlY1N0YXJ0PS8vOyBw
```

```
IH0nIC1lICcvXkV4ZWNTdGFydD0uKlteXFxdJC8geyBzL15FeGVjU3RhcnQ9Ly87IHAgfScgJEZJTEUp
CgppZiBbWyAkRU5WRklMRSBdXTsgdGhlbgogIFZBUk5BTUU9JHtWQVJOQU1FOi1FWEVDU1RBUl
R9CiAgZWNobyAiJHtWQVJOQU1FfT0ke0VYRUNTVEFSVH0iID4gJEVOVkZJTEUKZWxzZQogIGVja
G8gJEVYRUNTVEFSVApmaQo=
          mode: 493
          path: /usr/local/bin/extractExecStart
        - contents:
            source: data:text/plain;charset=utf-
8;base64,IyEvYmluL2Jhc2gKbnNlbnRlciAtLW1vdW50PS9ydW4vY29udGFpbmVyLW1vdW50LW5hbWV
zcGFjZS9tbnQgIiRAIgo=
          mode: 493
          path: /usr/local/bin/nsenterCmns
    systemd:
      units:
        - contents: |
            [Unit]
            Description=Manages a mount namespace that both kubelet and crio can use to share their
container-specific mounts

            [Service]
            Type=oneshot
            RemainAfterExit=yes
            RuntimeDirectory=container-mount-namespace
            Environment=RUNTIME_DIRECTORY=%t/container-mount-namespace
            Environment=BIND_POINT=%t/container-mount-namespace/mnt
            ExecStartPre=bash -c "findmnt ${RUNTIME_DIRECTORY} || mount --make-unbindable --
bind ${RUNTIME_DIRECTORY} ${RUNTIME_DIRECTORY}"
            ExecStartPre=touch ${BIND_POINT}
            ExecStart=unshare --mount=${BIND_POINT} --propagation slave mount --make-rshared /
            ExecStop=umount -R ${RUNTIME_DIRECTORY}
          name: container-mount-namespace.service
        - dropins:
            - contents: |
                [Unit]
                Wants=container-mount-namespace.service
                After=container-mount-namespace.service

                [Service]
                ExecStartPre=/usr/local/bin/extractExecStart %n /%t/%N-execstart.env
ORIG_EXECSTART
                EnvironmentFile=-/%t/%N-execstart.env
                ExecStart=
                ExecStart=bash -c "nsenter --mount=%t/container-mount-namespace/mnt \
                    ${ORIG_EXECSTART}"
              name: 90-container-mount-namespace.conf
          name: crio.service
        - dropins:
            - contents: |
                [Unit]
                Wants=container-mount-namespace.service
                After=container-mount-namespace.service

                [Service]
                ExecStartPre=/usr/local/bin/extractExecStart %n /%t/%N-execstart.env
ORIG_EXECSTART
                EnvironmentFile=-/%t/%N-execstart.env
          ExecStart=
          ExecStart=bash -c "nsenter --mount=%t/container-mount-namespace/mnt \
            ${ORIG_EXECSTART} --housekeeping-interval=30s"
        name: 90-container-mount-namespace.conf
      - contents: |
          [Service]
          Environment="OPENSHIFT_MAX_HOUSEKEEPING_INTERVAL_DURATION=60s"
          Environment="OPENSHIFT_EVICTION_MONITORING_PERIOD_DURATION=30s"
        name: 30-kubelet-interval-tuning.conf
      name: kubelet.service
```

6.6.3. SCTP

Stream Control Transmission Protocol (SCTP) is a key protocol used in RAN applications. This **MachineConfig** object adds the SCTP kernel module to the node to enable this protocol.

Recommended control plane node SCTP configuration (03-sctp-machine-config-master.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: load-sctp-module-master
spec:
  config:
    ignition:
      version: 2.2.0
    storage:
      files:
        - contents:
            source: data:,
            verification: {}
          filesystem: root
          mode: 420
          path: /etc/modprobe.d/sctp-blacklist.conf
        - contents:
            source: data:text/plain;charset=utf-8,sctp
          filesystem: root
          mode: 420
          path: /etc/modules-load.d/sctp-load.conf
```

Recommended worker node SCTP configuration (03-sctp-machine-config-worker.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: load-sctp-module-worker
spec:
  config:
    ignition:
      version: 2.2.0
    storage:
      files:
        - contents:
            source: data:,
            verification: {}
          filesystem: root
          mode: 420
          path: /etc/modprobe.d/sctp-blacklist.conf
        - contents:
            source: data:text/plain;charset=utf-8,sctp
          filesystem: root
          mode: 420
          path: /etc/modules-load.d/sctp-load.conf
```

6.6.4. Setting rcu_normal

The following **MachineConfig** CR configures the system to set **rcu_normal** to 1 after the system has finished startup. This improves kernel latency for vDU applications.

Recommended configuration for disabling rcu_expedited after the node has finished startup (08-set-rcu-normal-master.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 08-set-rcu-normal-master
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,IyEvYmluL2Jhc2gKIwojIERpc2FibGUgcmN1X2V4cGVkaXRlZCBhZnRlciBub2RlIGhhcyBmaW
5pc2hlZCBib290aW5nCiMKIyBUaGUgZGVmYXVsdHMgYmVsb3cgY2FuIGJlIG92ZXJyaWRkZW4gdml
hIGVudmlyb25tZW50IHZhcmlhYmxlcwojCgojIERlZmF1bHQgd2FpdCB0aW1lIGlzIDYwMHMgPSAxMG
06Ck1BWElNVU1fV0FJVF9USU1FPSR7TUFYSU1VTV9XQUlUX1RJTUU6LTYwMH0KCiMgRGVmY
XVsdCBzdGVhZHktc3RhdGUgdGhyZXNob2xkID0gMiUKIyBBbGxvd2VkIHZhbHVlczoKIyAgNCAgLSBh
YnNvbHV0ZSBwb2QgY291bnQgKCsvLSkKIyAgNCUgLSBwZXJjZW50IGNoYW5nZSAoKy8tKQojICAt
MSAtIGRpc2FibGUgdGhlIHN0ZWFkeS1zdGF0ZSBjaGVjawpTVEVBRFlfU1RBVEVfVEhSRVNIT0xEP
SR7U1RFQURZX1NUQVRFX1RIUkVTSE9MRDotMiV9CgojIERlZmF1bHQgc3RlYWR5LXN0YXRlIHd
pbmRvdyA9IDYwcwojIElmIHRoZSBydW5uaW5nIHBvZCBjb3VudCBzdGF5cyB3aXRoaW4gdGhlIGdpd
mVuIHRocmVzaG9sZCBmb3IgdGhpcyB0aW1lCiMgcGVyaW9kLCByZXR1cm4gQ1BVIHV0aWxpemF0
aW9uIHRvIG5vcm1hbCBiZWZvcmUgdGhlIG1heGltdW0gd2FpdCB0aW1lIGhhcwojIGV4cGlyZXMKU1
RFQURZX1NUQVRFX1dJTkRPVz0ke1NURUFEWV9TVEFURV9XSU5ET1c6LTYwfQoKIyBEZWZhd
Wx0IHN0ZWFkeS1zdGF0ZSBhbGxvd3MgYW55IHBvZCBjb3VudCB0byBiZSAic3RlYWR5IHN0YXRlIgo
jIEluY3JlYXNpbmcgdGhpcyB3aWxsIHNraXAgYW55IHN0ZWFkeS1zdGF0ZSBjaGVja3MgdW50aWwgd
GhlIGNvdW50IHJpc2VzIGFib3ZlCiMgdGhpcyBudW1iZXIgdG8gYXZvaWQgZmFsc2UgcG9zaXRpdmV
zIGlmIHRoZXJlIGFyZSBzb21lIHBlcmlvZHMgd2hlcmUgdGhlCiMgY291bnQgZG9lc24ndCBpbmNyZWF
zZSBidXQgd2Uga25vdyB3ZSBjYW4ndCBiZSBhdCBzdGVhZHktc3RhdGUgeWV0LgpTVEVBRFlfU1RB
VEVfTUlOSU1VTT0ke1NURUFEWV9TVEFURV9NSU5JTVVNOi0wfQoKIyMjIyMjIyMjIyMjIyMjI
```

```
yMjIyMjIyMjIyMjIyMjIyMjIyMjIyMjIyMjIyMjIyMjIwoKd2l0aGluKCkgewogIGxvY2FsIGxhc3Q9JDEgY3Vycm
udD0kMiB0aHJlc2hvbGQ9JDMKICBsb2NhbCBkZWx0YT0wIHBjaGFuZ2UKICBkZWx0YT0kKCggY3Vy
cmVudCAtIGxhc3QgKSkKICBpZiBbWyAkY3VycmVudCAtZXEgJGxhc3QgXV07IHRoZW4KICAgIHBjaG
FuZ2U9MAogIGVsaWYgW1sgJGxhc3QgLWVxIDAgXV07IHRoZW4KICAgIHBjaGFuZ2U9MTAwMDA
wMAogIGVsc2UKICAgIHBjaGFuZ2U9JCgoICggIiRkZWx0YSIgKiAxMDApIC8gbGFzdCApKQogIGZpCi
AgZWNobyAtbiAibGFzdDokbGFzdCBjdXJyZW50OiRjdXJyZW50IGRlbHRhOiRkZWx0YSBwY2hhbmdl
OiR7cGNoYW5nZX0lOiAiCiAgbG9jYWwgYWJzb2x1dGUgbGltaXQKICBjYXNlICR0aHJlc2hvbGQgaW4
KICAgIColKQogICAgICBhYnNvbHV0ZT0ke3BjaGFuZ2UjIy19ICMgYWJzb2x1dGUgdmFsdWUKICAgI
CAgbGltaXQ9JHt0aHJlc2hvbGQlJSV9CiAgICAgIDs7CiAgICAqKQogICAgICBhYnNvbHV0ZT0ke2RlbH
RhIyMtfSAjIGFic29sdXRlIHZhbHVlCiAgICAgIGxpbWl0PSR0aHJlc2hvbGQKICAgICAgOzsKICBlc2FjCiA
gaWYgW1sgJGFic29sdXRlIC1sZSAkbGltaXQgXV07IHRoZW4KICAgIGVjaG8gIndpdGhpbiAoKy8tKSR
0aHJlc2hvbGQiCiAgICByZXR1cm4gMAogIGVsc2UKICAgIGVjaG8gIm91dHNpZGUgKCsvLSkkdGhyZ
XNob2xkIgogICAgcmV0dXJuIDEKICBmaQp9CgpzdGVhZHlzdGF0ZSgpIHsKICBsb2NhbCBsYXN0PS
QxIGN1cnJlbnQ9JDIKICBpZiBbWyAkbGFzdCAtbHQgJFNURUFEWV9TVEFURV9NSU5JTVVNIF1dO
yB0aGVuCiAgICBlY2hvICJsYXN0OiRsYXN0IGN1cnJlbnQ6JGN1cnJlbnQgV2FpdGluZyB0byByZWFja
CAkU1RFQURZX1NUQVRFX01JTklNVU0gYmVmb3JlIGNoZWNraW5nIGZvciBzdGVhZHktc3RhdGUi
CiAgICByZXR1cm4gMQogIGZpCiAgd2l0aGluICIkbGFzdCIgIiRjdXJyZW50IiAiJFNURUFEWV9TVEFU
RV9USFJFU0hPTEQiCn0KCndhaXRGb3JSZWFkeSgpIHsKICBsb2dnZXIgIlJlY292ZXJ5OiBXYWl0aW
5nICR7TUFYSU1VTV9XQUlUX1RJTUV9cyBmb3IgdGhlIGluaXRpYWxpemF0aW9uIHRvIGNvbXBsZX
RlIgogIGxvY2FsIHQ9MCBzPTEwCiAgbG9jYWwgbGFzdENjb3VudD0wIGNjb3VudD0wIHN0ZWFkeVN
0YXRlVGltZT0wCiAgd2hpbGUgW1sgJHQgLWx0ICRNQVhJTVVNX1dBSVRfVElNRSBdXTsgZG8KIC
AgIHNsZWVwICRzCiAgICAoKHQgKz0gcykpCiAgICAjIERldGVjdCBzdGVhZHktc3RhdGUgcG9kIGNvd
W50CiAgICBjY291bnQ9JChjcmljdGwgcHMgMj4vZGV2L251bGwgfCB3YyAtbCkKICAgIGlmIFtbICRjY2
91bnQgLWd0IDAgXV0gJiYgc3RlYWR5c3RhdGUgIiRsYXN0Q2NvdW50IiAiJGNjb3VudCI7IHRoZW4KI
CAgICAgKChzdGVhZHlTdGF0ZVRpbWUgKz0gcykpCiAgICAgIGVjaG8gIlN0ZWFkeS1zdGF0ZSBmb3
IgJHtzdGVhZHlTdGF0ZVRpbWV9cy8ke1NURUFEWV9TVEFURV9XSU5ET1d9cyIKICAgICAgaWYgW
1sgJHN0ZWFkeVN0YXRlVGltZSAtZ2UgJFNURUFEWV9TVEFURV9XSU5ET1cgXV07IHRoZW4KICA
gICAgICBsb2dnZXIgIlJlY292ZXJ5OiBTdGVhZHktc3RhdGUgKCsvLSAkU1RFQURZX1NUQVRFX1RI
UkVTSE9MRCkgZm9yICR7U1RFQURZX1NUQVRFX1dJTkRPV31zOiBEb25lIgogICAgICAgIHJldHVy
biAwCiAgICAgIGZpCiAgICBlbHNlCiAgICAgIGlmIFtbICRzdGVhZHlTdGF0ZVRpbWUgLWd0IDAgXV07
IHRoZW4KICAgICAgICBlY2hvICJSZXNldHRpbmcgc3RlYWR5LXN0YXRlIHRpbWVyIgogICAgICAgIHN
0ZWFkeVN0YXRlVGltZT0wCiAgICAgIGZpCiAgICBmaQogICAgbGFzdENjb3VudD0kY2NvdW50CiAgZ
G9uZQogIGxvZ2dlciAiUmVjb3Zlcnk6IFJlY292ZXJ5IENvbXBsZXRlIFRpbWVvdXQiCn0KCnNldFJjdU5vc
m1hbCgpIHsKICBlY2hvICJTZXR0aW5nIHJjdV9ub3JtYWwgdG8gMSIKICBlY2hvIDEgPiAvc3lzL2tlcm5lb
C9yY3Vfbm9ybWFsCn0KCm1haW4oKSB7CiAgd2FpdEZvclJlYWR5CiAgZWNobyAiV2FpdGluZyBmb3Ig
gc3RlYWR5IHN0YXRlIHRvb2s6ICQoYXdrICd7cHJpbnQgaW50KCQxLzM2MDApImgiLCBpbnQoKCQ
xJTM2MDApLzYwKSJtIiwgaW50KCQxJTYwKSJzIn0nIC9wcm9jL3VwdGltZSkiCiAgc2V0UmN1Tm9yb
WFsCn0KCmlmIFtbICIke0JBU0hfU09VUkNFWzBdfSIgPSAiJHswfSIgXV07IHRoZW4KICBtYWluICIke0
B9IgogIGV4aXQgJD8KZmkK
```

```
          mode: 493
          path: /usr/local/bin/set-rcu-normal.sh
    systemd:
      units:
        - contents: |
            [Unit]
            Description=Disable rcu_expedited after node has finished booting by setting rcu_normal to 1

            [Service]
            Type=simple
            ExecStart=/usr/local/bin/set-rcu-normal.sh

            # Maximum wait time is 600s = 10m:
            Environment=MAXIMUM_WAIT_TIME=600

            # Steady-state threshold = 2%
            # Allowed values:
```

```
          #  4  - absolute pod count (+/-)
          #  4% - percent change (+/-)
          #  -1 - disable the steady-state check
          # Note: '%' must be escaped as '%%' in systemd unit files
          Environment=STEADY_STATE_THRESHOLD=2%%

          # Steady-state window = 120s
          # If the running pod count stays within the given threshold for this time
          # period, return CPU utilization to normal before the maximum wait time has
          # expires
          Environment=STEADY_STATE_WINDOW=120

          # Steady-state minimum = 40
          # Increasing this will skip any steady-state checks until the count rises above
          # this number to avoid false positives if there are some periods where the
          # count doesn't increase but we know we can't be at steady-state yet.
          Environment=STEADY_STATE_MINIMUM=40

          [Install]
          WantedBy=multi-user.target
        enabled: true
        name: set-rcu-normal.service
```

6.6.5. Automatic kernel crash dumps with kdump

kdump is a Linux kernel feature that creates a kernel crash dump when the kernel crashes. **kdump** is enabled with the following **MachineConfig** CRs.

Recommended **MachineConfig** CR to remove ice driver from control plane kdump logs (**05-kdump-config-master.yaml**)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 05-kdump-config-master
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - enabled: true
          name: kdump-remove-ice-module.service
          contents: |
            [Unit]
            Description=Remove ice module when doing kdump
            Before=kdump.service
            [Service]
            Type=oneshot
            RemainAfterExit=true
            ExecStart=/usr/local/bin/kdump-remove-ice-module.sh
            [Install]
            WantedBy=multi-user.target
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,IyEvdXNyL2Jpbi9lbnYgYmFzaAoKIyBUaGlzIHNjcmlwdCByZW1vdmVzIHRoZSBpY2UgbW9k
dWxlIGZyb20ga2R1bXAgdG8gcHJldmVudCBrZHVtcCBmYWlsdXJlcyBvbiBjZXJ0YWluIHNlcnZlcnMuCi
MgVGhpcyBpcyBhIHRlbXBvcmFyeSB3b3JrYXJvdW5kIGZvciBSSEVMUExBTi0xMzgyMzYgYW5kIGNh
iBiZSByZW1vdmVkIHdoZW4gdGhhdCBpc3N1ZSBpcwojIGZpeGVkLgoKc2V0IC14CgpTRUQ9Ii91c3Iv
YmluL3NlZCIKR1JFUD0iL3Vzci9iaW4vZ3JlcCIKCiMgb3ZlcnJpZGUgZm9yIHRlc3RpbmcgcHVycG9zZX
MKS0RVTVBfQ09ORj0iJHsxOi0vZXRjL3N5c2NvbmZpZy9rZHVtcH0iClJFTU9WRV9JQ0VfU1RSPSJtb
2R1bGVfYmxhY2tsaXN0PWljZSIKCiMgZXhpdCBpZiBmaWxlIGRvZXNuJ3QgZXhpc3QKWyAhIC1mIC
R7S0RVTVBfQ09ORn0gXSAmJiBleGl0IDAKCiMgZXhpdCBpZiBmaWxlIGFscmVhZHkgdXBkYXRlZAok
e0dSRVB9IC1GcSAke1JFTU9WRV9JQ0VfU1RSfSAke0tEVU1QX0NPTkZ9ICYmIGV4aXQgMAoKIyB
UYXJnZXQgbGluZSBsb29rcyBzb21ldGhpbmcgbGlrZSB0aGlzOgojIEtEVU1QX0NPTU1BTkRMSU5FX
0FQUEVORD0iaXJxcG9sbCBucl9jcHVzPTEgLi4uIGhlc3RfZGlzYWJsZSIKIyBVc2Ugc2VkIHRvIG1hdG
NoIGV2ZXJ5dGhpbmcgYmV0d2VlbiB0aGUgcXVvdGVzIGFuZCBhcHBlbmQgdGhlIFJFTU9WRV9JQ0
VfU1RSIHRvIGl0CiR7U0VEfSAtaSAncy9eS0RVTVBfQ09NTUFORExJTkVfQVBQRU5EPSJbXiJdKi8m
ICcke1JFTU9WRV9JQ0VfU1RSfScvJyAke0tEVU1QX0NPTkZ9IHx8IGV4aXQgMAo=
          mode: 448
          path: /usr/local/bin/kdump-remove-ice-module.sh
```

Recommended control plane node kdump configuration (06-kdump-master.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 06-kdump-enable-master
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - enabled: true
          name: kdump.service
  kernelArguments:
    - crashkernel=512M
```

Recommended MachineConfig CR to remove ice driver from worker node kdump logs (05-kdump-config-worker.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 05-kdump-config-worker
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
          - enabled: true
            name: kdump-remove-ice-module.service
            contents: |
              [Unit]
              Description=Remove ice module when doing kdump
              Before=kdump.service
              [Service]
              Type=oneshot
              RemainAfterExit=true
              ExecStart=/usr/local/bin/kdump-remove-ice-module.sh
              [Install]
              WantedBy=multi-user.target
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,IyEvdXNyL2Jpbi9lbnYgYmFzaAoKIyBUaGlzIHNjcmlwdCByZW1vdmVzIHRoZSBpY2UgbW9k
dWxlIGZyb20ga2R1bXAgdG8gcHJldmVudCBrZHVtcCBmYWlsdXJlcyBvbiBjZXJ0YWluIHNlcnZlcnMuCi
MgVGhpcyBpcyBhIHRlbXBvcmFyeSB3b3JrYXJvdW5kIGZvciBSSEVMUExBTi0xMzgyMzYgYW5kIGNh
iBiZSByZW1vdmVkIHdoZW4gdGhhdCBpc3N1ZSBpcwojIGZpeGVkLgoKc2V0IC14CgpTRUQ9Ii91c3Iv
YmluL3NlZCIKR1JFUD0iL3Vzci9iaW4vZ3JlcCIKCiMgb3ZlcnJpZGUgZm9yIHRlc3RpbmcgcHVycG9zZX
MKS0RVTVBfQ09ORj0iJHsxOi0vZXRjL3N5c2NvbmZpZy9rZHVtcH0iClJFTU9WRV9JQ0VfU1RSPSJtb
2R1bGVfYmxhY2tsaXN0PWljZSIKCiMgZXhpdCBpZiBmaWxlIGRvZXNuJ3QgZXhpc3QKWyAhIC1mIC
R7S0RVTVBfQ09ORn0gXSAmJiBleGl0IDAKCiMgZXhpdCBpZiBmaWxlIGFscmVhZHkgdXBkYXRlZAok
e0dSRVB9IC1GcSAke1JFTU9WRV9JQ0VfU1RSfSAke0tEVU1QX0NPTkZ9ICYmIGV4aXQgMAoKIyB
UYXJnZXQgbGluZSBsb29rcyBzb21ldGhpbmcgbGlrZSB0aGlzOgojIEtEVU1QX0NPTU1BTkRMSU5FX
0FQUEVORD0iaXJxcG9sbCBucl9jcHVzPTEgLi4uIGhlc3RfZGlzYWJsZSIKIyBVc2Ugc2VkIHRvIG1hdG
NoIGV2ZXJ5dGhpbmcgYmV0d2VlbiB0aGUgcXVvdGVzIGFuZCBhcHBlbmQgdGhlIFJFTU9WRV9JQ0
VfU1RSIHRvIGl0CiR7U0VEfSAtaSAncy9eS0RVTVBfQ09NTUFOREExJTkVfQVBQRU5EPSJbXiJdKi8m
ICcke1JFTU9WRV9JQ0VfU1RSfScvJyAke0tEVU1QX0NPTkZ9IHx8IGV4aXQgMAo=
          mode: 448
          path: /usr/local/bin/kdump-remove-ice-module.sh
```

Recommended kdump worker node configuration (**06-kdump-worker.yaml**)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 06-kdump-enable-worker
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - enabled: true
          name: kdump.service
  kernelArguments:
    - crashkernel=512M
```

6.6.6. Disable automatic CRI-O cache wipe

After an uncontrolled host shutdown or cluster reboot, CRI-O automatically deletes the entire CRI-O cache, causing all images to be pulled from the registry when the node reboots. This can result in unacceptably slow recovery times or recovery failures. To prevent this from happening in single-node OpenShift clusters that you install with GitOps ZTP, disable the CRI-O delete cache feature during cluster installation.

Recommended **MachineConfig** CR to disable CRI-O cache wipe on control plane nodes (**99-crio-disable-wipe-master.yaml**)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 99-crio-disable-wipe-master
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,W2NyaW9dCmNsZWFuX3NodXRkb3duX2ZpbGUgPSAiIgo=
          mode: 420
          path: /etc/crio/crio.conf.d/99-crio-disable-wipe.toml
```

Recommended **MachineConfig** CR to disable CRI-O cache wipe on worker nodes (**99-crio-disable-wipe-worker.yaml**)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 99-crio-disable-wipe-worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-
8;base64,W2NyaW9dCmNsZWFuX3NodXRkb3duX2ZpbGUgPSAiIgo=
          mode: 420
          path: /etc/crio/crio.conf.d/99-crio-disable-wipe.toml
```

6.6.7. Configuring crun as the default container runtime

The following **ContainerRuntimeConfig** custom resources (CRs) configure crun as the default OCI container runtime for control plane and worker nodes. The crun container runtime is fast and lightweight and has a low memory footprint.

IMPORTANT

For optimal performance, enable crun for control plane and worker nodes in single-node OpenShift, three-node OpenShift, and standard clusters. To avoid the cluster rebooting when the CR is applied, apply the change as a GitOps ZTP additional Day 0 install-time manifest.

Recommended ContainerRuntimeConfig CR for control plane nodes (enable-crun-master.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: ContainerRuntimeConfig
metadata:
  name: enable-crun-master
spec:
  machineConfigPoolSelector:
    matchLabels:
      pools.operator.machineconfiguration.openshift.io/master: ""
  containerRuntimeConfig:
    defaultRuntime: crun
```

Recommended ContainerRuntimeConfig CR for worker nodes (enable-crun-worker.yaml)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: ContainerRuntimeConfig
metadata:
  name: enable-crun-worker
spec:
  machineConfigPoolSelector:
    matchLabels:
      pools.operator.machineconfiguration.openshift.io/worker: ""
  containerRuntimeConfig:
    defaultRuntime: crun
```

6.7. RECOMMENDED POSTINSTALLATION CLUSTER CONFIGURATIONS

When the cluster installation is complete, the ZTP pipeline applies the following custom resources (CRs) that are required to run DU workloads.

NOTE

In GitOps ZTP v4.10 and earlier, you configure UEFI secure boot with a **MachineConfig** CR. This is no longer required in GitOps ZTP v4.11 and later. In v4.11, you configure UEFI secure boot for single-node OpenShift clusters by updating the **spec.clusters.nodes.bootMode** field in the **SiteConfig** CR that you use to install the cluster. For more information, see Deploying a managed cluster with SiteConfig and GitOps ZTP.

6.7.1. Operators

Single-node OpenShift clusters that run DU workloads require the following Operators to be installed:

- Local Storage Operator
- Logging Operator
- PTP Operator
- SR-IOV Network Operator

You also need to configure a custom **CatalogSource** CR, disable the default **OperatorHub** configuration, and configure an **ImageContentSourcePolicy** mirror registry that is accessible from the clusters that you install.

Recommended Storage Operator namespace and Operator group configuration (StorageNS.yaml, StorageOperGroup.yaml)

```
---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-local-storage
  annotations:
    workload.openshift.io/allowed: management
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: openshift-local-storage
  namespace: openshift-local-storage
  annotations: {}
spec:
  targetNamespaces:
    - openshift-local-storage
```

Recommended Cluster Logging Operator namespace and Operator group configuration (ClusterLogNS.yaml, ClusterLogOperGroup.yaml)

```
---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-logging
  annotations:
    workload.openshift.io/allowed: management
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: cluster-logging
  namespace: openshift-logging
  annotations: {}
spec:
  targetNamespaces:
    - openshift-logging
```

Recommended PTP Operator namespace and Operator group configuration (**PtpSubscriptionNS.yaml, PtpSubscriptionOperGroup.yaml**)

```
---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-ptp
  annotations:
    workload.openshift.io/allowed: management
  labels:
    openshift.io/cluster-monitoring: "true"
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: ptp-operators
  namespace: openshift-ptp
  annotations: {}
spec:
  targetNamespaces:
    - openshift-ptp
```

Recommended SR-IOV Operator namespace and Operator group configuration (**SriovSubscriptionNS.yaml, SriovSubscriptionOperGroup.yaml**)

```
---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-sriov-network-operator
  annotations:
    workload.openshift.io/allowed: management
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: sriov-network-operators
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  targetNamespaces:
    - openshift-sriov-network-operator
```

Recommended **CatalogSource** configuration (**DefaultCatsrc.yaml**)

```
apiVersion: operators.coreos.com/v1alpha1
kind: CatalogSource
metadata:
  name: default-cat-source
  namespace: openshift-marketplace
  annotations:
    target.workload.openshift.io/management: '{"effect": "PreferredDuringScheduling"}'
spec:
  displayName: default-cat-source
  image: $imageUrl
  publisher: Red Hat
  sourceType: grpc
  updateStrategy:
    registryPoll:
      interval: 1h
status:
  connectionState:
    lastObservedState: READY
```

Recommended **ImageContentSourcePolicy** configuration (**DisconnectedICSP.yaml**)

```
apiVersion: operator.openshift.io/v1alpha1
kind: ImageContentSourcePolicy
metadata:
  name: disconnected-internal-icsp
  annotations: {}
spec:
  repositoryDigestMirrors:
    - $mirrors
```

Recommended **OperatorHub** configuration (**OperatorHub.yaml**)

```
apiVersion: config.openshift.io/v1
kind: OperatorHub
metadata:
  name: cluster
  annotations: {}
spec:
  disableAllDefaultSources: true
```

6.7.2. Operator subscriptions

Single-node OpenShift clusters that run DU workloads require the following **Subscription** CRs. The subscription provides the location to download the following Operators:

- Local Storage Operator
- Logging Operator
- PTP Operator
- SR-IOV Network Operator
- SRIOV-FEC Operator

For each Operator subscription, specify the channel to get the Operator from. The recommended channel is **stable**.

You can specify **Manual** or **Automatic** updates. In **Automatic** mode, the Operator automatically updates to the latest versions in the channel as they become available in the registry. In **Manual** mode, new Operator versions are installed only when they are explicitly approved.

TIP

Use **Manual** mode for subscriptions. This allows you to control the timing of Operator updates to fit within scheduled maintenance windows.

Recommended Local Storage Operator subscription (**StorageSubscription.yaml**)

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: local-storage-operator
  namespace: openshift-local-storage
  annotations: {}
spec:
  channel: "stable"
  name: local-storage-operator
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

Recommended SR-IOV Operator subscription (**SriovSubscription.yaml**)

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: sriov-network-operator-subscription
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  channel: "stable"
  name: sriov-network-operator
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

Recommended PTP Operator subscription (**PtpSubscription.yaml**)

```
---
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: ptp-operator-subscription
  namespace: openshift-ptp
  annotations: {}
spec:
  channel: "stable"
  name: ptp-operator
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

Recommended Cluster Logging Operator subscription (**ClusterLogSubscription.yaml**)

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: cluster-logging
  namespace: openshift-logging
  annotations: {}
spec:
  channel: "stable"
  name: cluster-logging
  source: redhat-operators-disconnected
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

6.7.3. Cluster logging and log forwarding

Single-node OpenShift clusters that run DU workloads require logging and log forwarding for debugging. The following **ClusterLogging** and **ClusterLogForwarder** custom resources (CRs) are required.

Recommended cluster logging configuration (**ClusterLogging.yaml**)

```
apiVersion: logging.openshift.io/v1
kind: ClusterLogging
metadata:
  name: instance
  namespace: openshift-logging
  annotations: {}
spec:
  managementState: "Managed"
  collection:
    logs:
      type: "vector"
```

Recommended log forwarding configuration (**ClusterLogForwarder.yaml**)

```
apiVersion: "logging.openshift.io/v1"
kind: ClusterLogForwarder
metadata:
  name: instance
  namespace: openshift-logging
  annotations: {}
spec:
  outputs: $outputs
  pipelines: $pipelines
```

Set the **spec.outputs.url** field to the URL of the Kafka server where the logs are forwarded to.

6.7.4. Performance profile

Single-node OpenShift clusters that run DU workloads require a Node Tuning Operator performance profile to use real-time host capabilities and services.

NOTE

In earlier versions of OpenShift Container Platform, the Performance Addon Operator was used to implement automatic tuning to achieve low latency performance for OpenShift applications. In OpenShift Container Platform 4.11 and later, this functionality is part of the Node Tuning Operator.

The following example **PerformanceProfile** CR illustrates the required single-node OpenShift cluster configuration.

Recommended performance profile configuration (**PerformanceProfile.yaml**)

```
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  # if you change this name make sure the 'include' line in TunedPerformancePatch.yaml
  # matches this name: include=openshift-node-performance-${PerformanceProfile.metadata.name}
  # Also in file 'validatorCRs/informDuValidator.yaml':
  # name: 50-performance-${PerformanceProfile.metadata.name}
  name: openshift-node-performance-profile
  annotations:
    ran.openshift.io/reference-configuration: "ran-du.redhat.com"
spec:
  additionalKernelArgs:
    - "rcupdate.rcu_normal_after_boot=0"
    - "efi=runtime"
    - "vfio_pci.enable_sriov=1"
    - "vfio_pci.disable_idle_d3=1"
    - "module_blacklist=irdma"
  cpu:
    isolated: $isolated
    reserved: $reserved
  hugepages:
    defaultHugepagesSize: $defaultHugepagesSize
    pages:
      - size: $size
        count: $count
        node: $node
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/$mcp: ""
  nodeSelector:
    node-role.kubernetes.io/$mcp: ''
  numa:
    topologyPolicy: "restricted"
  # To use the standard (non-realtime) kernel, set enabled to false
  realTimeKernel:
    enabled: true
  workloadHints:
    # WorkloadHints defines the set of upper level flags for different type of workloads.
    # See https://github.com/openshift/cluster-node-tuning-
operator/blob/master/docs/performanceprofile/performance_profile.md#workloadhints
    # for detailed descriptions of each item.
    # The configuration below is set for a low latency, performance mode.
    realTime: true
    highPowerConsumption: false
    perPodPowerManagement: false
```

Table 6.3. PerformanceProfile CR options for single-node OpenShift clusters

PerformanceProfile CR field	Description
metadata.name	Ensure that **name** matches the following fields set in related GitOps ZTP custom resources (CRs): ● **include=openshift-node-performance-${PerformanceProfile.metadata.name}** in **TunedPerformancePatch.yaml** ● **name: 50-performance-${PerformanceProfile.metadata.name}** in **validatorCRs/informDuValidator.yaml**
spec.additionalKernelArgs	**"efi=runtime"** Configures UEFI secure boot for the cluster host.
spec.cpu.isolated	Set the isolated CPUs. Ensure all of the Hyper-Threading pairs match. IMPORTANT The reserved and isolated CPU pools must not overlap and together must span all available cores. CPU cores that are not accounted for cause an undefined behaviour in the system.
spec.cpu.reserved	Set the reserved CPUs. When workload partitioning is enabled, system processes, kernel threads, and system container threads are restricted to these CPUs. All CPUs that are not isolated should be reserved.
spec.hugepages.pages	● Set the number of huge pages (**count**) ● Set the huge pages size (**size**). ● Set **node** to the NUMA node where the **hugepages** are allocated (**node**)

PerformanceProfile CR field	Description
spec.realTimeKernel	Set **enabled** to **true** to use the realtime kernel.
spec.workloadHints	Use **workloadHints** to define the set of top level flags for different type of workloads. The example configuration configures the cluster for low latency and high performance.

6.7.5. Configuring cluster time synchronization

Run a one-time system time synchronization job for control plane or worker nodes.

Recommended one time time-sync for control plane nodes (**99-sync-time-once-master.yaml**)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 99-sync-time-once-master
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - contents: |
            [Unit]
            Description=Sync time once
            After=network-online.target
            Wants=network-online.target
            [Service]
            Type=oneshot
            TimeoutStartSec=300
            ExecCondition=/bin/bash -c 'systemctl is-enabled chronyd.service --quiet && exit 1 || exit 0'
            ExecStart=/usr/sbin/chronyd -n -f /etc/chrony.conf -q
            RemainAfterExit=yes
            [Install]
            WantedBy=multi-user.target
          enabled: true
          name: sync-time-once.service
```

Recommended one time time-sync for worker nodes (**99-sync-time-once-worker.yaml**)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 99-sync-time-once-worker
spec:
  config:
    ignition:
      version: 3.2.0
    systemd:
      units:
        - contents: |
            [Unit]
            Description=Sync time once
            After=network-online.target
            [Service]
            Type=oneshot
            TimeoutStartSec=300
            ExecCondition=/bin/bash -c 'systemctl is-enabled chronyd.service --quiet && exit 1 || exit 0'
            ExecStart=/usr/sbin/chronyd -n -f /etc/chrony.conf -q
            RemainAfterExit=yes
            [Install]
            WantedBy=multi-user.target
          enabled: true
          name: sync-time-once.service
```

6.7.6. PTP

Single-node OpenShift clusters use Precision Time Protocol (PTP) for network time synchronization. The following example **PtpConfig** CRs illustrate the required PTP configurations for ordinary clocks, boundary clocks, and grandmaster clocks. The exact configuration you apply will depend on the node hardware and specific use case.

Recommended PTP ordinary clock configuration (PtpConfigSlave.yaml)

```
apiVersion: ptp.openshift.io/v1
kind: PtpConfig
metadata:
  name: slave
  namespace: openshift-ptp
  annotations: {}
spec:
  profile:
    - name: "slave"
      # The interface name is hardware-specific
      interface: $interface
      ptp4lOpts: "-2 -s"
      phc2sysOpts: "-a -r -n 24"
      ptpSchedulingPolicy: SCHED_FIFO
      ptpSchedulingPriority: 10
      ptpSettings:
        logReduce: "true"
      ptp4lConf: |
        [global]
        #
        # Default Data Set
        #
        twoStepFlag 1
        slaveOnly 1
        priority1 128
        priority2 128
```

```
domainNumber 24
#utc_offset 37
clockClass 255
clockAccuracy 0xFE
offsetScaledLogVariance 0xFFFF
free_running 0
freq_est_interval 1
dscp_event 0
dscp_general 0
dataset_comparison G.8275.x
G.8275.defaultDS.localPriority 128
#
# Port Data Set
#
logAnnounceInterval -3
logSyncInterval -4
logMinDelayReqInterval -4
logMinPdelayReqInterval -4
announceReceiptTimeout 3
syncReceiptTimeout 0
delayAsymmetry 0
fault_reset_interval -4
neighborPropDelayThresh 20000000
masterOnly 0
G.8275.portDS.localPriority 128
#
# Run time options
#
assume_two_step 0
logging_level 6
path_trace_enabled 0
follow_up_info 0
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 7
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
```

```
        pi_integral_norm_max 0.3
        step_threshold 2.0
        first_step_threshold 0.00002
        max_frequency 900000000
        clock_servo pi
        sanity_freq_limit 200000000
        ntpshm_segment 0
        #
        # Transport options
        #
        transportSpecific 0x0
        ptp_dst_mac 01:1B:19:00:00:00
        p2p_dst_mac 01:80:C2:00:00:0E
        udp_ttl 1
        udp6_scope 0x0E
        uds_address /var/run/ptp4l
        #
        # Default interface options
        #
        clock_type OC
        network_transport L2
        delay_mechanism E2E
        time_stamping hardware
        tsproc_mode filter
        delay_filter moving_median
        delay_filter_length 10
        egressLatency 0
        ingressLatency 0
        boundary_clock_jbod 0
        #
        # Clock description
        #
        productDescription ;;
        revisionData ;;
        manufacturerIdentity 00:00:00
        userDescription ;
        timeSource 0xA0
  recommend:
    - profile: "slave"
      priority: 4
      match:
        - nodeLabel: "node-role.kubernetes.io/$mcp"
```

Recommended boundary clock configuration (PtpConfigBoundary.yaml)

```
apiVersion: ptp.openshift.io/v1
kind: PtpConfig
metadata:
  name: boundary
  namespace: openshift-ptp
  annotations: {}
spec:
  profile:
    - name: "boundary"
      ptp4lOpts: "-2"
```

```
phc2sysOpts: "-a -r -n 24"
ptpSchedulingPolicy: SCHED_FIFO
ptpSchedulingPriority: 10
ptpSettings:
  logReduce: "true"
ptp4lConf: |
  # The interface name is hardware-specific
  [$iface_slave]
  masterOnly 0
  [$iface_master_1]
  masterOnly 1
  [$iface_master_2]
  masterOnly 1
  [$iface_master_3]
  masterOnly 1
  [global]
  #
  # Default Data Set
  #
  twoStepFlag 1
  slaveOnly 0
  priority1 128
  priority2 128
  domainNumber 24
  #utc_offset 37
  clockClass 248
  clockAccuracy 0xFE
  offsetScaledLogVariance 0xFFFF
  free_running 0
  freq_est_interval 1
  dscp_event 0
  dscp_general 0
  dataset_comparison G.8275.x
  G.8275.defaultDS.localPriority 128
  #
  # Port Data Set
  #
  logAnnounceInterval -3
  logSyncInterval -4
  logMinDelayReqInterval -4
  logMinPdelayReqInterval -4
  announceReceiptTimeout 3
  syncReceiptTimeout 0
  delayAsymmetry 0
  fault_reset_interval -4
  neighborPropDelayThresh 20000000
  masterOnly 0
  G.8275.portDS.localPriority 128
  #
  # Run time options
  #
  assume_two_step 0
  logging_level 6
  path_trace_enabled 0
  follow_up_info 0
  hybrid_e2e 0
```

```
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 135
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
max_frequency 900000000
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type BC
network_transport L2
delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
egressLatency 0
ingressLatency 0
boundary_clock_jbod 0
#
# Clock description
#
productDescription ;;
```

```
        revisionData ;;
        manufacturerIdentity 00:00:00
        userDescription ;
        timeSource 0xA0
  recommend:
    - profile: "boundary"
      priority: 4
      match:
        - nodeLabel: "node-role.kubernetes.io/$mcp"
```

Recommended PTP Westport Channel e810 grandmaster clock configuration (**PtpConfigGmWpc.yaml**)

```
apiVersion: ptp.openshift.io/v1
kind: PtpConfig
metadata:
  name: grandmaster
  namespace: openshift-ptp
  annotations: {}
spec:
  profile:
    - name: "grandmaster"
      ptp4lOpts: "-2 --summary_interval -4"
      phc2sysOpts: -r -u 0 -m -O -37 -N 8 -R 16 -s $iface_master -n 24
      ptpSchedulingPolicy: SCHED_FIFO
      ptpSchedulingPriority: 10
      ptpSettings:
        logReduce: "true"
      plugins:
        e810:
          enableDefaultConfig: false
          settings:
            LocalMaxHoldoverOffSet: 1500
            LocalHoldoverTimeout: 14400
            MaxInSpecOffset: 100
          pins: $e810_pins
          #  "$iface_master":
          #    "U.FL2": "0 2"
          #    "U.FL1": "0 1"
          #    "SMA2": "0 2"
          #    "SMA1": "0 1"
          ublxCmds:
            - args: #ubxtool -P 29.20 -z CFG-HW-ANT_CFG_VOLTCTRL,1
                - "-P"
                - "29.20"
                - "-z"
                - "CFG-HW-ANT_CFG_VOLTCTRL,1"
              reportOutput: false
            - args: #ubxtool -P 29.20 -e GPS
                - "-P"
                - "29.20"
                - "-e"
                - "GPS"
              reportOutput: false
            - args: #ubxtool -P 29.20 -d Galileo
          - "-P"
          - "29.20"
          - "-d"
          - "Galileo"
        reportOutput: false
      - args: #ubxtool -P 29.20 -d GLONASS
          - "-P"
          - "29.20"
          - "-d"
          - "GLONASS"
        reportOutput: false
      - args: #ubxtool -P 29.20 -d BeiDou
          - "-P"
          - "29.20"
          - "-d"
          - "BeiDou"
        reportOutput: false
      - args: #ubxtool -P 29.20 -d SBAS
          - "-P"
          - "29.20"
          - "-d"
          - "SBAS"
        reportOutput: false
      - args: #ubxtool -P 29.20 -t -w 5 -v 1 -e SURVEYIN,600,50000
          - "-P"
          - "29.20"
          - "-t"
          - "-w"
          - "5"
          - "-v"
          - "1"
          - "-e"
          - "SURVEYIN,600,50000"
        reportOutput: true
      - args: #ubxtool -P 29.20 -p MON-HW
          - "-P"
          - "29.20"
          - "-p"
          - "MON-HW"
        reportOutput: true
    ts2phcOpts: " "
    ts2phcConf: |
      [nmea]
      ts2phc.master 1
      [global]
      use_syslog  0
      verbose 1
      logging_level 7
      ts2phc.pulsewidth 100000000
      #cat /dev/GNSS to find available serial port
      #example value of gnss_serialport is /dev/ttyGNSS_1700_0
      ts2phc.nmea_serialport $gnss_serialport
      leapfile  /usr/share/zoneinfo/leap-seconds.list
      [$iface_master]
      ts2phc.extts_polarity rising
      ts2phc.extts_correction 0
```

```
ptp4lConf: |
  [$iface_master]
  masterOnly 1
  [$iface_master_1]
  masterOnly 1
  [$iface_master_2]
  masterOnly 1
  [$iface_master_3]
  masterOnly 1
  [global]
  #
  # Default Data Set
  #
  twoStepFlag 1
  priority1 128
  priority2 128
  domainNumber 24
  #utc_offset 37
  clockClass 6
  clockAccuracy 0x27
  offsetScaledLogVariance 0xFFFF
  free_running 0
  freq_est_interval 1
  dscp_event 0
  dscp_general 0
  dataset_comparison G.8275.x
  G.8275.defaultDS.localPriority 128
  #
  # Port Data Set
  #
  logAnnounceInterval -3
  logSyncInterval -4
  logMinDelayReqInterval -4
  logMinPdelayReqInterval 0
  announceReceiptTimeout 3
  syncReceiptTimeout 0
  delayAsymmetry 0
  fault_reset_interval -4
  neighborPropDelayThresh 20000000
  masterOnly 0
  G.8275.portDS.localPriority 128
  #
  # Run time options
  #
  assume_two_step 0
  logging_level 6
  path_trace_enabled 0
  follow_up_info 0
  hybrid_e2e 0
  inhibit_multicast_service 0
  net_sync_monitor 0
  tc_spanning_tree 0
  tx_timestamp_timeout 50
  unicast_listen 0
  unicast_master_table 0
  unicast_req_duration 3600
```

```
      use_syslog 1
      verbose 0
      summary_interval -4
      kernel_leap 1
      check_fup_sync 0
      clock_class_threshold 7
      #
      # Servo Options
      #
      pi_proportional_const 0.0
      pi_integral_const 0.0
      pi_proportional_scale 0.0
      pi_proportional_exponent -0.3
      pi_proportional_norm_max 0.7
      pi_integral_scale 0.0
      pi_integral_exponent 0.4
      pi_integral_norm_max 0.3
      step_threshold 2.0
      first_step_threshold 0.00002
      clock_servo pi
      sanity_freq_limit  200000000
      ntpshm_segment 0
      #
      # Transport options
      #
      transportSpecific 0x0
      ptp_dst_mac 01:1B:19:00:00:00
      p2p_dst_mac 01:80:C2:00:00:0E
      udp_ttl 1
      udp6_scope 0x0E
      uds_address /var/run/ptp4l
      #
      # Default interface options
      #
      clock_type BC
      network_transport L2
      delay_mechanism E2E
      time_stamping hardware
      tsproc_mode filter
      delay_filter moving_median
      delay_filter_length 10
      egressLatency 0
      ingressLatency 0
      boundary_clock_jbod 0
      #
      # Clock description
      #
      productDescription ;;
      revisionData ;;
      manufacturerIdentity 00:00:00
      userDescription ;
      timeSource 0x20
recommend:
  - profile: "grandmaster"
```

```
      priority: 4
      match:
        - nodeLabel: "node-role.kubernetes.io/$mcp"
```

The following optional **PtpOperatorConfig** CR configures PTP events reporting for the node.

Recommended PTP events configuration (PtpOperatorConfigForEvent.yaml)

```
apiVersion: ptp.openshift.io/v1
kind: PtpOperatorConfig
metadata:
  name: default
  namespace: openshift-ptp
  annotations: {}
spec:
  daemonNodeSelector:
    node-role.kubernetes.io/$mcp: ""
  ptpEventConfig:
    enableEventPublisher: true
    transportHost: "http://ptp-event-publisher-service-NODE_NAME.openshift-
ptp.svc.cluster.local:9043"
```

6.7.7. Extended Tuned profile

Single-node OpenShift clusters that run DU workloads require additional performance tuning configurations necessary for high-performance workloads. The following example **Tuned** CR extends the **Tuned** profile:

Recommended extended Tuned profile configuration (TunedPerformancePatch.yaml)

```
apiVersion: tuned.openshift.io/v1
kind: Tuned
metadata:
  name: performance-patch
  namespace: openshift-cluster-node-tuning-operator
  annotations:
    ran.openshift.io/ztp-deploy-wave: "10"
spec:
  profile:
    - name: performance-patch
      # Please note:
      # - The 'include' line must match the associated PerformanceProfile name, following below
pattern
      #   include=openshift-node-performance-${PerformanceProfile.metadata.name}
      # - When using the standard (non-realtime) kernel, remove the kernel.timer_migration override
from
      #   the [sysctl] section and remove the entire section if it is empty.
      data: |
        [main]
        summary=Configuration changes profile inherited from performance created tuned
        include=openshift-node-performance-openshift-node-performance-profile
        [scheduler]
        group.ice-ptp=0:f:10:*:ice-ptp.*
        group.ice-gnss=0:f:10:*:ice-gnss.*
      group.ice-dplls=0:f:10:*:ice-dplls.*
      [service]
      service.stalld=start,enable
      service.chronyd=stop,disable
  recommend:
  - machineConfigLabels:
      machineconfiguration.openshift.io/role: "$mcp"
    priority: 19
    profile: performance-patch
```

Table 6.4. **Tuned** CR options for single-node OpenShift clusters

Tuned CR field	Description
spec.profile.data	● The **include** line that you set in **spec.profile.data** must match the associated **PerformanceProfile** CR name. For example, **include=openshift-node-performance-${PerformanceProfile.metadata.name}**.

6.7.8. SR-IOV

Single root I/O virtualization (SR-IOV) is commonly used to enable fronthaul and midhaul networks. The following YAML example configures SR-IOV for a single-node OpenShift cluster.

NOTE

The configuration of the **SriovNetwork** CR will vary depending on your specific network and infrastructure requirements.

Recommended SriovOperatorConfig CR configuration (SriovOperatorConfig.yaml)

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovOperatorConfig
metadata:
  name: default
  namespace: openshift-sriov-network-operator
  annotations:
    ran.openshift.io/ztp-deploy-wave: "10"
spec:
  configDaemonNodeSelector:
    "node-role.kubernetes.io/$mcp": ""
  # Injector and OperatorWebhook pods can be disabled (set to "false") below
  # to reduce the number of management pods. It is recommended to start with the
  # webhook and injector pods enabled, and only disable them after verifying the
  # correctness of user manifests.
  #   If the injector is disabled, containers using sr-iov resources must explicitly assign
  #   them in the  "requests"/"limits" section of the container spec, for example:
  #    containers:
  #    - name: my-sriov-workload-container
  #      resources:
```

```
#       limits:
#         openshift.io/<resource_name>:  "1"
#       requests:
#         openshift.io/<resource_name>:  "1"
enableInjector: false
enableOperatorWebhook: false
# Disable drain is needed for single-node OpenShift.
disableDrain: true
logLevel: 0
```

Table 6.5. **SriovOperatorConfig** CR options for single-node OpenShift clusters

SriovOperatorConfig CR field	Description

spec.enableInjector	Disable **Injector** pods to reduce the number of management pods. Start with the **Injector** pods enabled, and only disable them after verifying the user manifests. If the injector is disabled, containers that use SR-IOV resources must explicitly assign them in the **requests** and **limits** section of the container spec.
	
	For example:
	
	`containers:`
	`- name: my-sriov-workload-container`
	`  resources:`
	`    limits:`
	`      openshift.io/<resource_name>:  "1"`
	`    requests:`
	`      openshift.io/<resource_name>:  "1"`

spec.enableOperatorWebhook	Disable **OperatorWebhook** pods to reduce the number of management pods. Start with the **OperatorWebhook** pods enabled, and only disable them after verifying the user manifests.

Recommended **SriovNetwork** configuration (**SriovNetwork.yaml**)

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: ""
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  #  resourceName: ""
  networkNamespace: openshift-sriov-network-operator
#  vlan: ""
#  spoofChk: ""
#  ipam: ""
#  linkState: ""
#  maxTxRate: ""
# minTxRate: ""
# vlanQoS: ""
# trust: ""
# capabilities: ""
```

Table 6.6. **SriovNetwork** CR options for single-node OpenShift clusters

SriovNetwork CR field	Description
spec.vlan	Configure **vlan** with the VLAN for the midhaul network.

Recommended **SriovNetworkNodePolicy** CR configuration (**SriovNetworkNodePolicy.yaml**)

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: $name
  namespace: openshift-sriov-network-operator
  annotations: {}
spec:
  # The attributes for Mellanox/Intel based NICs as below.
  #     deviceType: netdevice/vfio-pci
  #     isRdma: true/false
  deviceType: $deviceType
  isRdma: $isRdma
  nicSelector:
    # The exact physical function name must match the hardware used
    pfNames: [$pfNames]
  nodeSelector:
    node-role.kubernetes.io/$mcp: ""
  numVfs: $numVfs
  priority: $priority
  resourceName: $resourceName
```

Table 6.7. **SriovNetworkPolicy** CR options for single-node OpenShift clusters

SriovNetworkNodePolicy CR field	Description
spec.deviceType	Configure **deviceType** as **vfio-pci** or **netdevice**. For Mellanox NICs, set **deviceType: netdevice**, and **isRdma: true**. For Intel based NICs, set **deviceType: vfio-pci** and **isRdma: false**.
spec.nicSelector.pfNames	Specifies the interface connected to the fronthaul network.
spec.numVfs	Specifies the number of VFs for the fronthaul network.

SriovNetworkNodePolicy CR field	Description
spec.nicSelector.pfNames	The exact name of physical function must match the hardware.

Recommended SR-IOV kernel configurations (**07-sriov-related-kernel-args-master.yaml**)

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 07-sriov-related-kernel-args-master
spec:
  config:
    ignition:
      version: 3.2.0
  kernelArguments:
    - intel_iommu=on
    - iommu=pt
```

6.7.9. Console Operator

Use the cluster capabilities feature to prevent the Console Operator from being installed. When the node is centrally managed it is not needed. Removing the Operator provides additional space and capacity for application workloads.

To disable the Console Operator during the installation of the managed cluster, set the following in the **spec.clusters.0.installConfigOverrides** field of the **SiteConfig** custom resource (CR):

```
installConfigOverrides:  "{\"capabilities\":{\"baselineCapabilitySet\": \"None\" }}"
```

6.7.10. Alertmanager

Single-node OpenShift clusters that run DU workloads require reduced CPU resources consumed by the OpenShift Container Platform monitoring components. The following **ConfigMap** custom resource (CR) disables Alertmanager.

Recommended cluster monitoring configuration (**ReduceMonitoringFootprint.yaml**)

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster-monitoring-config
  namespace: openshift-monitoring
  annotations: {}
data:
  config.yaml: |
    alertmanagerMain:
      enabled: false
    telemeterClient:
```

```
    enabled: false
  prometheusK8s:
    retention: 24h
```

6.7.11. Operator Lifecycle Manager

Single-node OpenShift clusters that run distributed unit workloads require consistent access to CPU resources. Operator Lifecycle Manager (OLM) collects performance data from Operators at regular intervals, resulting in an increase in CPU utilisation. The following **ConfigMap** custom resource (CR) disables the collection of Operator performance data by OLM.

Recommended cluster OLM configuration (**ReduceOLMFootprint.yaml**)

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: collect-profiles-config
  namespace: openshift-operator-lifecycle-manager
data:
  pprof-config.yaml: |
    disabled: True
```

6.7.12. LVM Storage

You can dynamically provision local storage on single-node OpenShift clusters with Logical Volume Manager (LVM) Storage.

NOTE

The recommended storage solution for single-node OpenShift is the Local Storage Operator. Alternatively, you can use LVM Storage but it requires additional CPU resources to be allocated.

The following YAML example configures the storage of the node to be available to OpenShift Container Platform applications.

Recommended **LVMCluster** configuration (**StorageLVMCluster.yaml**)

```
apiVersion: lvm.topolvm.io/v1alpha1
kind: LVMCluster
metadata:
  name: odf-lvmcluster
  namespace: openshift-storage
spec:
  storage:
    deviceClasses:
    - name: vg1
      deviceSelector:
        paths:
        - /usr/disk/by-path/pci-0000:11:00.0-nvme-1
      thinPoolConfig:
        name: thin-pool-1
        overprovisionRatio: 10
        sizePercent: 90
```

Table 6.8. **LVMCluster** CR options for single-node OpenShift clusters

LVMCluster CR field	Description
deviceSelector.paths	Configure the disks used for LVM storage. If no disks are specified, the LVM Storage uses all the unused disks in the specified thin pool.

6.7.13. Network diagnostics

Single-node OpenShift clusters that run DU workloads require less inter-pod network connectivity checks to reduce the additional load created by these pods. The following custom resource (CR) disables these checks.

Recommended network diagnostics configuration (**DisableSnoNetworkDiag.yaml**)

```
apiVersion: operator.openshift.io/v1
kind: Network
metadata:
  name: cluster
  annotations: {}
spec:
  disableNetworkDiagnostics: true
```

Additional resources

- Deploying far edge sites using ZTP

CHAPTER 7. VALIDATING SINGLE-NODE OPENSHIFT CLUSTER TUNING FOR VDU APPLICATION WORKLOADS

Before you can deploy virtual distributed unit (vDU) applications, you need to tune and configure the cluster host firmware and various other cluster configuration settings. Use the following information to validate the cluster configuration to support vDU workloads.

Additional resources

- Workload partitioning in single-node OpenShift with GitOps ZTP
- Reference configuration for deploying vDUs on single-node OpenShift

7.1. RECOMMENDED FIRMWARE CONFIGURATION FOR VDU CLUSTER HOSTS

Use the following table as the basis to configure the cluster host firmware for vDU applications running on OpenShift Container Platform 4.16.

NOTE

The following table is a general recommendation for vDU cluster host firmware configuration. Exact firmware settings will depend on your requirements and specific hardware platform. Automatic setting of firmware is not handled by the zero touch provisioning pipeline.

Table 7.1. Recommended cluster host firmware settings

Firmware setting	Configuration	Description
HyperTransport (HT)	Enabled	HyperTransport (HT) bus is a bus technology developed by AMD. HT provides a high-speed link between the components in the host memory and other system peripherals.
UEFI	Enabled	Enable booting from UEFI for the vDU host.
CPU Power and Performance Policy	Performance	Set CPU Power and Performance Policy to optimize the system for performance over energy efficiency.
Uncore Frequency Scaling	Disabled	Disable Uncore Frequency Scaling to prevent the voltage and frequency of non-core parts of the CPU from being set independently.
Uncore Frequency	Maximum	Sets the non-core parts of the CPU such as cache and memory controller to their maximum possible frequency of operation.
Performance P-limit	Disabled	Disable Performance P-limit to prevent the Uncore frequency coordination of processors.

Firmware setting	Configuration	Description
Enhanced Intel® SpeedStep Tech	Enabled	Enable Enhanced Intel SpeedStep to allow the system to dynamically adjust processor voltage and core frequency that decreases power consumption and heat production in the host.
Intel® Turbo Boost Technology	Enabled	Enable Turbo Boost Technology for Intel-based CPUs to automatically allow processor cores to run faster than the rated operating frequency if they are operating below power, current, and temperature specification limits.
Intel Configurable TDP	Enabled	Enables Thermal Design Power (TDP) for the CPU.
Configurable TDP Level	Level 2	TDP level sets the CPU power consumption required for a particular performance rating. TDP level 2 sets the CPU to the most stable performance level at the cost of power consumption.
Energy Efficient Turbo	Disabled	Disable Energy Efficient Turbo to prevent the processor from using an energy-efficiency based policy.
Hardware P-States	Enabled or Disabled	Enable OS-controlled P-States to allow power saving configurations. Disable **P-states** (performance states) to optimize the operating system and CPU for performance over power consumption.
Package C-State	C0/C1 state	Use C0 or C1 states to set the processor to a fully active state (C0) or to stop CPU internal clocks running in software (C1).
C1E	Disabled	CPU Enhanced Halt (C1E) is a power saving feature in Intel chips. Disabling C1E prevents the operating system from sending a halt command to the CPU when inactive.
Processor C6	Disabled	C6 power-saving is a CPU feature that automatically disables idle CPU cores and cache. Disabling C6 improves system performance.
Sub-NUMA Clustering	Disabled	Sub-NUMA clustering divides the processor cores, cache, and memory into multiple NUMA domains. Disabling this option can increase performance for latency-sensitive workloads.

NOTE

Enable global SR-IOV and VT-d settings in the firmware for the host. These settings are relevant to bare-metal environments.

NOTE

Enable both **C-states** and OS-controlled **P-States** to allow per pod power management.

7.2. RECOMMENDED CLUSTER CONFIGURATIONS TO RUN VDU APPLICATIONS

Clusters running virtualized distributed unit (vDU) applications require a highly tuned and optimized configuration. The following information describes the various elements that you require to support vDU workloads in OpenShift Container Platform 4.16 clusters.

7.2.1. Recommended cluster MachineConfig CRs for single-node OpenShift clusters

Check that the **MachineConfig** custom resources (CRs) that you extract from the **ztp-site-generate** container are applied in the cluster. The CRs can be found in the extracted **out/source-crs/extra-manifest/** folder.

The following **MachineConfig** CRs from the **ztp-site-generate** container configure the cluster host:

Table 7.2. Recommended GitOps ZTP MachineConfig CRs

MachineConfig CR	Description
01-container-mount-ns-and-kubelet-conf-master.yaml **01-container-mount-ns-and-kubelet-conf-worker.yaml**	Configures the container mount namespace and kubelet configuration.
03-sctp-machine-config-master.yaml **03-sctp-machine-config-worker.yaml**	Loads the SCTP kernel module. These **MachineConfig** CRs are optional and can be omitted if you do not require this kernel module.
05-kdump-config-master.yaml **05-kdump-config-worker.yaml** **06-kdump-master.yaml** **06-kdump-worker.yaml**	Configures kdump crash reporting for the cluster.
07-sriov-related-kernel-args-master.yaml	Configures SR-IOV kernel arguments in the cluster.
08-set-rcu-normal-master.yaml **08-set-rcu-normal-worker.yaml**	Disables **rcu_expedited** mode after the cluster has rebooted.
99-crio-disable-wipe-master.yaml **99-crio-disable-wipe-worker.yaml**	Disables the automatic CRI-O cache wipe following cluster reboot.

MachineConfig CR	Description
99-sync-time-once-master.yaml **99-sync-time-once-worker.yaml**	Configures the one-time check and adjustment of the system clock by the Chrony service.
enable-crun-master.yaml **enable-crun-worker.yaml**	Enables the **crun** OCI container runtime.
extra-manifest/enable-cgroups-v1.yaml **source-crs/extra-manifest/enable-cgroups-v1.yaml**	Enables cgroups v1 during cluster installation and when generating RHACM cluster policies.

NOTE

In OpenShift Container Platform 4.14 and later, you configure workload partitioning with the **cpuPartitioningMode** field in the **SiteConfig** CR.

Additional resources

- Workload partitioning in single-node OpenShift with GitOps ZTP
- Extracting source CRs from the ztp-site-generate container

7.2.2. Recommended cluster Operators

The following Operators are required for clusters running virtualized distributed unit (vDU) applications and are a part of the baseline reference configuration:

- Node Tuning Operator (NTO). NTO packages functionality that was previously delivered with the Performance Addon Operator, which is now a part of NTO.
- PTP Operator
- SR-IOV Network Operator
- Red Hat OpenShift Logging Operator
- Local Storage Operator

7.2.3. Recommended cluster kernel configuration

Always use the latest supported real-time kernel version in your cluster. Ensure that you apply the following configurations in the cluster:

1. Ensure that the following **additionalKernelArgs** are set in the cluster performance profile:

```
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
# ...
spec:
  additionalKernelArgs:
  - "rcupdate.rcu_normal_after_boot=0"
  - "efi=runtime"
  - "vfio_pci.enable_sriov=1"
  - "vfio_pci.disable_idle_d3=1"
  - "module_blacklist=irdma"

  # ...
```

2. Optional: Set the CPU frequency under the **hardwareTuning** field:
   You can use hardware tuning to tune CPU frequencies for reserved and isolated core CPUs. For FlexRAN like applications, hardware vendors recommend that you run CPU frequencies below the default provided frequencies. It is highly recommended that, before setting any frequencies, you refer to the hardware vendor's guidelines for maximum frequency settings for your processor generation. This example shows the frequencies for reserved and isolated CPUs for Sapphire Rapid hardware:

```
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: openshift-node-performance-profile
spec:
      cpu:
        isolated: "2-19,22-39"
        reserved: "0-1,20-21"
      hugepages:
        defaultHugepagesSize: 1G
        pages:
          - size: 1G
            count: 32
      realTimeKernel:
          enabled: true
      hardwareTuning:
          isolatedCpuFreq: 2500000
          reservedCpuFreq: 2800000
```

3. Ensure that the **performance-patch** profile in the **Tuned** CR configures the correct CPU isolation set that matches the **isolated** CPU set in the related **PerformanceProfile** CR, for example:

```
apiVersion: tuned.openshift.io/v1
kind: Tuned
metadata:
  name: performance-patch
  namespace: openshift-cluster-node-tuning-operator
  annotations:
    ran.openshift.io/ztp-deploy-wave: "10"
spec:
  profile:
    - name: performance-patch
      # The 'include' line must match the associated PerformanceProfile name, for example:
      # include=openshift-node-performance-${PerformanceProfile.metadata.name}
      # When using the standard (non-realtime) kernel, remove the kernel.timer_migration
override from the [sysctl] section
      data: |
        [main]
        summary=Configuration changes profile inherited from performance created tuned
        include=openshift-node-performance-openshift-node-performance-profile
        [scheduler]
        group.ice-ptp=0:f:10:*:ice-ptp.*
        group.ice-gnss=0:f:10:*:ice-gnss.*
        group.ice-dplls=0:f:10:*:ice-dplls.*
        [service]
        service.stalld=start,enable
        service.chronyd=stop,disable
# ...
```

7.2.4. Checking the realtime kernel version

Always use the latest version of the realtime kernel in your OpenShift Container Platform clusters. If you are unsure about the kernel version that is in use in the cluster, you can compare the current realtime kernel version to the release version with the following procedure.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You are logged in as a user with **cluster-admin** privileges.
- You have installed **podman**.

Procedure

1. Run the following command to get the cluster version:

   ```
   $ OCP_VERSION=$(oc get clusterversion version -o jsonpath='{.status.desired.version}{"\n"}')
   ```

2. Get the release image SHA number:

   ```
   $ DTK_IMAGE=$(oc adm release info --image-for=driver-toolkit quay.io/openshift-release-dev/ocp-release:$OCP_VERSION-x86_64)
   ```

3. Run the release image container and extract the kernel version that is packaged with cluster's current release:

   ```
   $ podman run --rm $DTK_IMAGE rpm -qa | grep 'kernel-rt-core-' | sed 's#kernel-rt-core-##'
   ```

   Example output

   ```
   4.18.0-305.49.1.rt7.121.el8_4.x86_64
   ```

   This is the default realtime kernel version that ships with the release.

   NOTE

   The realtime kernel is denoted by the string **.rt** in the kernel version.

Verification

Check that the kernel version listed for the cluster's current release matches actual realtime kernel that is running in the cluster. Run the following commands to check the running realtime kernel version:

1. Open a remote shell connection to the cluster node:

   ```
   $ oc debug node/<node_name>
   ```

2. Check the realtime kernel version:

   ```
   sh-4.4# uname -r
   ```

   Example output

   ```
   4.18.0-305.49.1.rt7.121.el8_4.x86_64
   ```

7.3. CHECKING THAT THE RECOMMENDED CLUSTER CONFIGURATIONS ARE APPLIED

You can check that clusters are running the correct configuration. The following procedure describes how to check the various configurations that you require to deploy a DU application in OpenShift Container Platform 4.16 clusters.

Prerequisites

- You have deployed a cluster and tuned it for vDU workloads.
- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.

Procedure

1. Check that the default OperatorHub sources are disabled. Run the following command:

   ```
   $ oc get operatorhub cluster -o yaml
   ```

   Example output

   ```
   spec:
     disableAllDefaultSources: true
   ```

2. Check that all required **CatalogSource** resources are annotated for workload partitioning (**PreferredDuringScheduling**) by running the following command:

   ```
   $ oc get catalogsource -A -o jsonpath='{range .items[*]}{.metadata.name}{" -- "}
   {.metadata.annotations.target\.workload\.openshift\.io/management}{"\n"}{end}'
   ```

   Example output

   ```
   certified-operators -- {"effect": "PreferredDuringScheduling"}
   ```

```
community-operators -- {"effect": "PreferredDuringScheduling"}
ran-operators (1)
redhat-marketplace -- {"effect": "PreferredDuringScheduling"}
redhat-operators -- {"effect": "PreferredDuringScheduling"}
```

(1) **CatalogSource** resources that are not annotated are also returned. In this example, the **ran-operators CatalogSource** resource is not annotated and does not have the **PreferredDuringScheduling** annotation.

NOTE

In a properly configured vDU cluster, only a single annotated catalog source is listed.

3. Check that all applicable OpenShift Container Platform Operator namespaces are annotated for workload partitioning. This includes all Operators installed with core OpenShift Container Platform and the set of additional Operators included in the reference DU tuning configuration. Run the following command:

```
$ oc get namespaces -A -o jsonpath='{range .items[*]}{.metadata.name}{" -- "}
{.metadata.annotations.workload\.openshift\.io/allowed}{"\n"}{end}'
```

Example output

```
default --
openshift-apiserver -- management
openshift-apiserver-operator -- management
openshift-authentication -- management
openshift-authentication-operator -- management
```

IMPORTANT

Additional Operators must not be annotated for workload partitioning. In the output from the previous command, additional Operators should be listed without any value on the right side of the **--** separator.

4. Check that the **ClusterLogging** configuration is correct. Run the following commands:

   a. Validate that the appropriate input and output logs are configured:

   ```
   $ oc get -n openshift-logging ClusterLogForwarder instance -o yaml
   ```

   Example output

   ```
   apiVersion: logging.openshift.io/v1
   kind: ClusterLogForwarder
   metadata:
     creationTimestamp: "2022-07-19T21:51:41Z"
     generation: 1
     name: instance
     namespace: openshift-logging
     resourceVersion: "1030342"
   ```

```
  uid: 8c1a842d-80c5-447a-9150-40350bdf40f0
spec:
  inputs:
  - infrastructure: {}
    name: infra-logs
  outputs:
  - name: kafka-open
    type: kafka
    url: tcp://10.46.55.190:9092/test
  pipelines:
  - inputRefs:
    - audit
    name: audit-logs
    outputRefs:
    - kafka-open
  - inputRefs:
    - infrastructure
    name: infrastructure-logs
    outputRefs:
    - kafka-open
...
```

b. Check that the curation schedule is appropriate for your application:

```
$ oc get -n openshift-logging clusterloggings.logging.openshift.io instance -o yaml
```

Example output

```
apiVersion: logging.openshift.io/v1
kind: ClusterLogging
metadata:
  creationTimestamp: "2022-07-07T18:22:56Z"
  generation: 1
  name: instance
  namespace: openshift-logging
  resourceVersion: "235796"
  uid: ef67b9b8-0e65-4a10-88ff-ec06922ea796
spec:
  collection:
    logs:
      fluentd: {}
      type: fluentd
  curation:
    curator:
      schedule: 30 3 * * *
    type: curator
  managementState: Managed
...
```

5. Check that the web console is disabled (**managementState: Removed**) by running the following command:

```
$ oc get consoles.operator.openshift.io cluster -o jsonpath="{ .spec.managementState }"
```

Example output

```
Removed
```

6. Check that **chronyd** is disabled on the cluster node by running the following commands:

```
$ oc debug node/<node_name>
```

Check the status of **chronyd** on the node:

```
sh-4.4# chroot /host
```

```
sh-4.4# systemctl status chronyd
```

Example output

```
● chronyd.service - NTP client/server
   Loaded: loaded (/usr/lib/systemd/system/chronyd.service; disabled; vendor preset:
enabled)
   Active: inactive (dead)
     Docs: man:chronyd(8)
           man:chrony.conf(5)
```

7. Check that the PTP interface is successfully synchronized to the primary clock using a remote shell connection to the **linuxptp-daemon** container and the PTP Management Client (**pmc**) tool:

   a. Set the **$PTP_POD_NAME** variable with the name of the **linuxptp-daemon** pod by running the following command:

   ```
   $ PTP_POD_NAME=$(oc get pods -n openshift-ptp -l app=linuxptp-daemon -o name)
   ```

   b. Run the following command to check the sync status of the PTP device:

   ```
   $ oc -n openshift-ptp rsh -c linuxptp-daemon-container ${PTP_POD_NAME} pmc -u -f
   /var/run/ptp4l.0.config -b 0 'GET PORT_DATA_SET'
   ```

   #### Example output

   ```
   sending: GET PORT_DATA_SET
     3cecef.fffe.7a7020-1 seq 0 RESPONSE MANAGEMENT PORT_DATA_SET
       portIdentity            3cecef.fffe.7a7020-1
       portState               SLAVE
       logMinDelayReqInterval  -4
       peerMeanPathDelay       0
       logAnnounceInterval     1
       announceReceiptTimeout  3
       logSyncInterval         0
       delayMechanism          1
       logMinPdelayReqInterval 0
       versionNumber           2
     3cecef.fffe.7a7020-2 seq 0 RESPONSE MANAGEMENT PORT_DATA_SET
   ```

```
    portIdentity          3cecef.fffe.7a7020-2
    portState             LISTENING
    logMinDelayReqInterval  0
    peerMeanPathDelay       0
    logAnnounceInterval     1
    announceReceiptTimeout  3
    logSyncInterval         0
    delayMechanism          1
    logMinPdelayReqInterval 0
    versionNumber           2
```

c. Run the following **pmc** command to check the PTP clock status:

```
$ oc -n openshift-ptp rsh -c linuxptp-daemon-container ${PTP_POD_NAME} pmc -u -f
/var/run/ptp4l.0.config -b 0 'GET TIME_STATUS_NP'
```

Example output

```
sending: GET TIME_STATUS_NP
  3cecef.fffe.7a7020-0 seq 0 RESPONSE MANAGEMENT TIME_STATUS_NP
    master_offset              10 (1)
    ingress_time               1657275432697400530
    cumulativeScaledRateOffset +0.000000000
    scaledLastGmPhaseChange    0
    gmTimeBaseIndicator        0
    lastGmPhaseChange          0x0000'0000000000000000.0000
    gmPresent                  true (2)
    gmIdentity                 3c2c30.ffff.670e00
```

(1) **master_offset** should be between -100 and 100 ns.

(2) Indicates that the PTP clock is synchronized to a master, and the local clock is not the grandmaster clock.

d. Check that the expected **master offset** value corresponding to the value in **/var/run/ptp4l.0.config** is found in the **linuxptp-daemon-container** log:

```
$ oc logs $PTP_POD_NAME -n openshift-ptp -c linuxptp-daemon-container
```

Example output

```
phc2sys[56020.341]: [ptp4l.1.config] CLOCK_REALTIME phc offset  -1731092 s2 freq -
1546242 delay    497
ptp4l[56020.390]: [ptp4l.1.config] master offset         -2 s2 freq  -5863 path delay       541
ptp4l[56020.390]: [ptp4l.0.config] master offset         -8 s2 freq  -10699 path delay       533
```

8. Check that the SR-IOV configuration is correct by running the following commands:

a. Check that the **disableDrain** value in the **SriovOperatorConfig** resource is set to **true**:

```
$ oc get sriovoperatorconfig -n openshift-sriov-network-operator default -o jsonpath="
{.spec.disableDrain}{'\n'}"
```

Example output

```
true
```

b. Check that the **SriovNetworkNodeState** sync status is **Succeeded** by running the following command:

```
$ oc get SriovNetworkNodeStates -n openshift-sriov-network-operator -o jsonpath="
{.items[*].status.syncStatus}{'\n'}"
```

Example output

```
Succeeded
```

c. Verify that the expected number and configuration of virtual functions (**Vfs**) under each interface configured for SR-IOV is present and correct in the **.status.interfaces** field. For example:

```
$ oc get SriovNetworkNodeStates -n openshift-sriov-network-operator -o yaml
```

Example output

```
apiVersion: v1
items:
- apiVersion: sriovnetwork.openshift.io/v1
  kind: SriovNetworkNodeState
...
  status:
    interfaces:
    ...
    - Vfs:
      - deviceID: 154c
        driver: vfio-pci
        pciAddress: 0000:3b:0a.0
        vendor: "8086"
        vfID: 0
      - deviceID: 154c
        driver: vfio-pci
        pciAddress: 0000:3b:0a.1
        vendor: "8086"
        vfID: 1
      - deviceID: 154c
        driver: vfio-pci
        pciAddress: 0000:3b:0a.2
        vendor: "8086"
        vfID: 2
      - deviceID: 154c
        driver: vfio-pci
        pciAddress: 0000:3b:0a.3
        vendor: "8086"
        vfID: 3
      - deviceID: 154c
        driver: vfio-pci
        pciAddress: 0000:3b:0a.4
      vendor: "8086"
      vfID: 4
    - deviceID: 154c
      driver: vfio-pci
      pciAddress: 0000:3b:0a.5
      vendor: "8086"
      vfID: 5
    - deviceID: 154c
      driver: vfio-pci
      pciAddress: 0000:3b:0a.6
      vendor: "8086"
      vfID: 6
    - deviceID: 154c
      driver: vfio-pci
      pciAddress: 0000:3b:0a.7
      vendor: "8086"
      vfID: 7
```

9. Check that the cluster performance profile is correct. The **cpu** and **hugepages** sections will vary depending on your hardware configuration. Run the following command:

```
$ oc get PerformanceProfile openshift-node-performance-profile -o yaml
```

Example output

```
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  creationTimestamp: "2022-07-19T21:51:31Z"
  finalizers:
  - foreground-deletion
  generation: 1
  name: openshift-node-performance-profile
  resourceVersion: "33558"
  uid: 217958c0-9122-4c62-9d4d-fdc27c31118c
spec:
  additionalKernelArgs:
  - idle=poll
  - rcupdate.rcu_normal_after_boot=0
  - efi=runtime
  cpu:
    isolated: 2-51,54-103
    reserved: 0-1,52-53
  hugepages:
    defaultHugepagesSize: 1G
    pages:
    - count: 32
      size: 1G
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/master: ""
  net:
    userLevelNetworking: true
  nodeSelector:
    node-role.kubernetes.io/master: ""
  numa:
    topologyPolicy: restricted
  realTimeKernel:
    enabled: true
status:
  conditions:
  - lastHeartbeatTime: "2022-07-19T21:51:31Z"
    lastTransitionTime: "2022-07-19T21:51:31Z"
    status: "True"
    type: Available
  - lastHeartbeatTime: "2022-07-19T21:51:31Z"
    lastTransitionTime: "2022-07-19T21:51:31Z"
    status: "True"
    type: Upgradeable
  - lastHeartbeatTime: "2022-07-19T21:51:31Z"
    lastTransitionTime: "2022-07-19T21:51:31Z"
    status: "False"
    type: Progressing
  - lastHeartbeatTime: "2022-07-19T21:51:31Z"
    lastTransitionTime: "2022-07-19T21:51:31Z"
    status: "False"
    type: Degraded
  runtimeClass: performance-openshift-node-performance-profile
  tuned: openshift-cluster-node-tuning-operator/openshift-node-performance-openshift-node-
performance-profile
```

NOTE

CPU settings are dependent on the number of cores available on the server and should align with workload partitioning settings. **hugepages** configuration is server and application dependent.

10. Check that the **PerformanceProfile** was successfully applied to the cluster by running the following command:

```
$ oc get performanceprofile openshift-node-performance-profile -o jsonpath="{range
.status.conditions[*]}{ @.type }{' -- '}{@.status}{'\n'}{end}"
```

Example output

```
Available -- True
Upgradeable -- True
Progressing -- False
Degraded -- False
```

11. Check the **Tuned** performance patch settings by running the following command:

```
$ oc get tuneds.tuned.openshift.io -n openshift-cluster-node-tuning-operator performance-
patch -o yaml
```

Example output

```
apiVersion: tuned.openshift.io/v1
kind: Tuned
```

```
metadata:
  creationTimestamp: "2022-07-18T10:33:52Z"
  generation: 1
  name: performance-patch
  namespace: openshift-cluster-node-tuning-operator
  resourceVersion: "34024"
  uid: f9799811-f744-4179-bf00-32d4436c08fd
spec:
  profile:
  - data: |
      [main]
      summary=Configuration changes profile inherited from performance created tuned
      include=openshift-node-performance-openshift-node-performance-profile
      [bootloader]
      cmdline_crash=nohz_full=2-23,26-47 (1)
      [sysctl]
      kernel.timer_migration=1
      [scheduler]
      group.ice-ptp=0:f:10:*:ice-ptp.*
      [service]
      service.stalld=start,enable
      service.chronyd=stop,disable
    name: performance-patch
  recommend:
  - machineConfigLabels:
      machineconfiguration.openshift.io/role: master
    priority: 19
    profile: performance-patch
```

(1) The cpu list in **cmdline=nohz_full=** will vary based on your hardware configuration.

12. Check that cluster networking diagnostics are disabled by running the following command:

```
$ oc get networks.operator.openshift.io cluster -o
jsonpath='{.spec.disableNetworkDiagnostics}'
```

Example output

```
true
```

13. Check that the **Kubelet** housekeeping interval is tuned to slower rate. This is set in the **containerMountNS** machine config. Run the following command:

```
$ oc describe machineconfig container-mount-namespace-and-kubelet-conf-master | grep
OPENSHIFT_MAX_HOUSEKEEPING_INTERVAL_DURATION
```

Example output

```
Environment="OPENSHIFT_MAX_HOUSEKEEPING_INTERVAL_DURATION=60s"
```

14. Check that Grafana and **alertManagerMain** are disabled and that the Prometheus retention period is set to 24h by running the following command:

```
$ oc get configmap cluster-monitoring-config -n openshift-monitoring -o jsonpath="{
.data.config\.yaml }"
```

Example output

```
grafana:
  enabled: false
alertmanagerMain:
  enabled: false
prometheusK8s:
   retention: 24h
```

a. Use the following commands to verify that Grafana and **alertManagerMain** routes are not found in the cluster:

```
$ oc get route -n openshift-monitoring alertmanager-main
```

```
$ oc get route -n openshift-monitoring grafana
```

Both queries should return **Error from server (NotFound)** messages.

15. Check that there is a minimum of 4 CPUs allocated as **reserved** for each of the **PerformanceProfile**, **Tuned** performance-patch, workload partitioning, and kernel command line arguments by running the following command:

```
$ oc get performanceprofile -o jsonpath="{ .items[0].spec.cpu.reserved }"
```

Example output

```
0-3
```

NOTE

Depending on your workload requirements, you might require additional reserved CPUs to be allocated.

CHAPTER 8. ADVANCED MANAGED CLUSTER CONFIGURATION WITH SITECONFIG RESOURCES

You can use **SiteConfig** custom resources (CRs) to deploy custom functionality and configurations in your managed clusters at installation time.

8.1. CUSTOMIZING EXTRA INSTALLATION MANIFESTS IN THE GITOPS ZTP PIPELINE

You can define a set of extra manifests for inclusion in the installation phase of the GitOps Zero Touch Provisioning (ZTP) pipeline. These manifests are linked to the **SiteConfig** custom resources (CRs) and are applied to the cluster during installation. Including **MachineConfig** CRs at install time makes the installation process more efficient.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. Create a set of extra manifest CRs that the GitOps ZTP pipeline uses to customize the cluster installs.

2. In your custom **/siteconfig** directory, create a subdirectory **/custom-manifest** for your extra manifests. The following example illustrates a sample **/siteconfig** with **/custom-manifest** folder:

```
siteconfig
├── site1-sno-du.yaml
├── site2-standard-du.yaml
├── extra-manifest/
└── custom-manifest
    └── 01-example-machine-config.yaml
```

NOTE

The subdirectory names **/custom-manifest** and **/extra-manifest** used throughout are example names only. There is no requirement to use these names and no restriction on how you name these subdirectories. In this example **/extra-manifest** refers to the Git subdirectory that stores the contents of **/extra-manifest** from the **ztp-site-generate** container.

3. Add your custom extra manifest CRs to the **siteconfig/custom-manifest** directory.

4. In your **SiteConfig** CR, enter the directory name in the **extraManifests.searchPaths** field, for example:

```
clusters:
- clusterName: "example-sno"
  networkType: "OVNKubernetes"
  extraManifests:
```

```
searchPaths:
  - extra-manifest/ 1
  - custom-manifest/ 2
```

1 Folder for manifests copied from the **ztp-site-generate** container.

2 Folder for custom manifests.

5. Save the **SiteConfig**, **/extra-manifest**, and **/custom-manifest** CRs, and push them to the site configuration repo.

During cluster provisioning, the GitOps ZTP pipeline appends the CRs in the **/custom-manifest** directory to the default set of extra manifests stored in **extra-manifest/**.

NOTE

As of version 4.14 **extraManifestPath** is subject to a deprecation warning.

While **extraManifestPath** is still supported, we recommend that you use **extraManifests.searchPaths**. If you define **extraManifests.searchPaths** in the **SiteConfig** file, the GitOps ZTP pipeline does not fetch manifests from the **ztp-site-generate** container during site installation.

If you define both **extraManifestPath** and **extraManifests.searchPaths** in the **Siteconfig** CR, the setting defined for **extraManifests.searchPaths** takes precedence.

It is strongly recommended that you extract the contents of **/extra-manifest** from the **ztp-site-generate** container and push it to the GIT repository.

8.2. FILTERING CUSTOM RESOURCES USING SITECONFIG FILTERS

By using filters, you can easily customize **SiteConfig** custom resources (CRs) to include or exclude other CRs for use in the installation phase of the GitOps Zero Touch Provisioning (ZTP) pipeline.

You can specify an **inclusionDefault** value of **include** or **exclude** for the **SiteConfig** CR, along with a list of the specific **extraManifest** RAN CRs that you want to include or exclude. Setting **inclusionDefault** to **include** makes the GitOps ZTP pipeline apply all the files in **/source-crs/extra-manifest** during installation. Setting **inclusionDefault** to **exclude** does the opposite.

You can exclude individual CRs from the **/source-crs/extra-manifest** folder that are otherwise included by default. The following example configures a custom single-node OpenShift **SiteConfig** CR to exclude the **/source-crs/extra-manifest/03-sctp-machine-config-worker.yaml** CR at installation time.

Some additional optional filtering scenarios are also described.

Prerequisites

- You configured the hub cluster for generating the required installation and policy CRs.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. To prevent the GitOps ZTP pipeline from applying the **03-sctp-machine-config-worker.yaml** CR file, apply the following YAML in the **SiteConfig** CR:

   ```
   apiVersion: ran.openshift.io/v1
   kind: SiteConfig
   metadata:
     name: "site1-sno-du"
     namespace: "site1-sno-du"
   spec:
     baseDomain: "example.com"
     pullSecretRef:
       name: "assisted-deployment-pull-secret"
     clusterImageSetNameRef: "openshift-4.16"
     sshPublicKey: "<ssh_public_key>"
     clusters:
   - clusterName: "site1-sno-du"
     extraManifests:
       filter:
         exclude:
           - 03-sctp-machine-config-worker.yaml
   ```

   The GitOps ZTP pipeline skips the **03-sctp-machine-config-worker.yaml** CR during installation. All other CRs in **/source-crs/extra-manifest** are applied.

2. Save the **SiteConfig** CR and push the changes to the site configuration repository.
   The GitOps ZTP pipeline monitors and adjusts what CRs it applies based on the **SiteConfig** filter instructions.

3. Optional: To prevent the GitOps ZTP pipeline from applying all the **/source-crs/extra-manifest** CRs during cluster installation, apply the following YAML in the **SiteConfig** CR:

   ```
   - clusterName: "site1-sno-du"
     extraManifests:
       filter:
         inclusionDefault: exclude
   ```

4. Optional: To exclude all the **/source-crs/extra-manifest** RAN CRs and instead include a custom CR file during installation, edit the custom **SiteConfig** CR to set the custom manifests folder and the **include** file, for example:

   ```
   clusters:
   - clusterName: "site1-sno-du"
     extraManifestPath: "<custom_manifest_folder>" 1
     extraManifests:
       filter:
         inclusionDefault: exclude  2
         include:
           - custom-sctp-machine-config-worker.yaml
   ```

   1 Replace **<custom_manifest_folder>** with the name of the folder that contains the custom installation CRs, for example, **user-custom-manifest/**.

   2 Set **inclusionDefault** to **exclude** to prevent the GitOps ZTP pipeline from applying the files in **/source-crs/extra-manifest** during installation.

The following example illustrates the custom folder structure:

```
siteconfig
  ├── site1-sno-du.yaml
  └── user-custom-manifest
        └── custom-sctp-machine-config-worker.yaml
```

8.3. DELETING A NODE BY USING THE SITECONFIG CR

By using a **SiteConfig** custom resource (CR), you can delete and reprovision a node. This method is more efficient than manually deleting the node.

Prerequisites

- You have configured the hub cluster to generate the required installation and policy CRs.
- You have created a Git repository in which you can manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as the source repository for the Argo CD application.

Procedure

1. Update the **SiteConfig** CR to include the **bmac.agent-install.openshift.io/remove-agent-and-node-on-delete=true** annotation:

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "cnfdf20"
  namespace: "cnfdf20"
spec:
  Clusters:
    nodes:
    - hostname: node6
      role: "worker"
      crAnnotations:
        add:
          BareMetalHost:
            bmac.agent-install.openshift.io/remove-agent-and-node-on-delete: true
# ...
```

2. Suppress the generation of the **BareMetalHost** CR by updating the **SiteConfig** CR to include the **crSuppression.BareMetalHost** annotation:

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "cnfdf20"
  namespace: "cnfdf20"
spec:
  clusters:
  - nodes:
    - hostName: node6
      role: "worker"
      crSuppression:
      - BareMetalHost
# ...
```

3. Push the changes to the Git repository and wait for deprovisioning to start. The status of the **BareMetalHost** CR should change to **deprovisioning**. Wait for the **BareMetalHost** to finish deprovisioning, and be fully deleted.

Verification

1. Verify that the **BareMetalHost** and **Agent** CRs for the worker node have been deleted from the hub cluster by running the following commands:

```
$ oc get bmh -n <cluster-ns>
```

```
$ oc get agent -n <cluster-ns>
```

2. Verify that the node record has been deleted from the spoke cluster by running the following command:

```
$ oc get nodes
```

NOTE

If you are working with secrets, deleting a secret too early can cause an issue because ArgoCD needs the secret to complete resynchronization after deletion. Delete the secret only after the node cleanup, when the current ArgoCD synchronization is complete.

Next Steps

To reprovision a node, delete the changes previously added to the **SiteConfig**, push the changes to the Git repository, and wait for the synchronization to complete. This regenerates the **BareMetalHost** CR of the worker node and triggers the re-install of the node.

CHAPTER 9. MANAGING CLUSTER POLICES WITH POLICYGENERATOR RESOURCES

9.1. CONFIGURING MANAGED CLUSTER POLICIES BY USING POLICYGENERATOR RESOURCES

Applied **Policy** custom resources (CRs) configure the managed clusters that you provision. You can customize how Red Hat Advanced Cluster Management (RHACM) uses **PolicyGenerator** CRs to generate the applied **Policy** CRs.

IMPORTANT

Using PolicyGenerator resources with GitOps ZTP is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

NOTE

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

9.1.1. Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

PolicyGenerator custom resources (CRs) and **PolicyGenTemplate** CRs can be used in GitOps ZTP to generate RHACM policies for managed clusters.

There are advantages to using **PolicyGenerator** CRs over **PolicyGenTemplate** CRs when it comes to patching OpenShift Container Platform resources with GitOps ZTP. Using the RHACM **PolicyGenerator** API provides a generic way of patching resources which is not possible with **PolicyGenTemplate** resources.

The **PolicyGenerator** API is a part of the Open Cluster Management standard, while the **PolicyGenTemplate** API is not. A comparison of **PolicyGenerator** and **PolicyGenTemplate** resource patching and placement strategies are described in the following table.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Table 9.1. Comparison of RHACM PolicyGenerator and PolicyGenTemplate patching

PolicyGenerator patching	PolicyGenTemplate patching
Uses Kustomize strategic merges for merging resources. For more information see Declarative Management of Kubernetes Objects Using Kustomize.	Works by replacing variables with their values as defined by the patch. This is less flexible than Kustomize merge strategies.
Supports **ManagedClusterSet** and **Binding** resources.	Does not support **ManagedClusterSet** and **Binding** resources.
Relies only on patching, no embedded variable substitution is required.	Overwrites variable values defined in the patch.
Does not support merging lists in merge patches. Replacing a list in a merge patch is supported.	Merging and replacing lists is supported in a limited fashion - you can only merge one object in the list.
Does not currently support the OpenAPI specification for resource patching. This means that additional directives are required in the patch to merge content that does not follow a schema, for example, **PtpConfig** resources.	Works by replacing fields and values with values as defined by the patch.
Requires additional directives, for example, **$patch: replace** in the patch to merge content that does not follow a schema.	Substitutes fields and values defined in the source CR with values defined in the patch, for example **$name**.
Can patch the **Name** and **Namespace** fields defined in the reference source CR, but only if the CR file has a single object.	Can patch the **Name** and **Namespace** fields defined in the reference source CR.

9.1.2. About the PolicyGenerator CRD

The **PolicyGenerator** custom resource definition (CRD) tells the **PolicyGen** policy generator what custom resources (CRs) to include in the cluster configuration, how to combine the CRs into the generated policies, and what items in those CRs need to be updated with overlay content.

The following example shows a **PolicyGenerator** CR (**acm-common-du-ranGen.yaml**) extracted from the **ztp-site-generate** reference container. The **acm-common-du-ranGen.yaml** file defines two Red Hat Advanced Cluster Management (RHACM) policies. The polices manage a collection of configuration CRs, one for each unique value of **policyName** in the CR. **acm-common-du-ranGen.yaml** creates a single placement binding and a placement rule to bind the policies to clusters based on the labels listed in the **policyDefaults.placement.labelSelector** section.

Example PolicyGenerator CR - acm-common-ranGen.yaml

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: common-latest
placementBindingDefaults:
  name: common-latest-placement-binding [1]
policyDefaults:
  namespace: ztp-common
  placement:
    labelSelector:
      matchExpressions:
        - key: common
          operator: In
          values:
            - "true"
        - key: du-profile
          operator: In
          values:
            - latest
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: common-latest-config-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "1"
    manifests:
      - path: source-crs/ReduceMonitoringFootprint.yaml
      - path: source-crs/DefaultCatsrc.yaml [2]
        patches:
          - metadata:
              name: redhat-operators-disconnected
            spec:
              displayName: disconnected-redhat-operators
              image: registry.example.com:5000/disconnected-redhat-operators/disconnected-redhat-
operator-index:v4.9
      - path: source-crs/DisconnectedICSP.yaml
        patches:
          - spec:
              repositoryDigestMirrors:
                - mirrors:
                    - registry.example.com:5000
                  source: registry.redhat.io
  - name: common-latest-subscriptions-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
```

```
manifests: 3
  - path: source-crs/SriovSubscriptionNS.yaml
  - path: source-crs/SriovSubscriptionOperGroup.yaml
  - path: source-crs/SriovSubscription.yaml
  - path: source-crs/SriovOperatorStatus.yaml
  - path: source-crs/PtpSubscriptionNS.yaml
  - path: source-crs/PtpSubscriptionOperGroup.yaml
  - path: source-crs/PtpSubscription.yaml
  - path: source-crs/PtpOperatorStatus.yaml
  - path: source-crs/ClusterLogNS.yaml
  - path: source-crs/ClusterLogOperGroup.yaml
  - path: source-crs/ClusterLogSubscription.yaml
  - path: source-crs/ClusterLogOperatorStatus.yaml
  - path: source-crs/StorageNS.yaml
  - path: source-crs/StorageOperGroup.yaml
  - path: source-crs/StorageSubscription.yaml
  - path: source-crs/StorageOperatorStatus.yaml
```

1 Applies the policies to all clusters with this label.

2 The **DefaultCatsrc.yaml** file contains the catalog source for the disconnected registry and related registry configuration details.

3 Files listed under **policies.manifests** create the Operator policies for installed clusters.

A **PolicyGenerator** CR can be constructed with any number of included CRs. Apply the following example CR in the hub cluster to generate a policy containing a single CR:

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: group-du-sno
placementBindingDefaults:
  name: group-du-sno-placement-binding
policyDefaults:
  namespace: ztp-group
  placement:
    labelSelector:
      matchExpressions:
        - key: group-du-sno
          operator: Exists
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: group-du-sno-config-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: '10'
```

```
manifests:
  - path: source-crs/PtpConfigSlave-MCP-master.yaml
    patches:
      - metadata: null
        name: du-ptp-slave
        namespace: openshift-ptp
        annotations:
          ran.openshift.io/ztp-deploy-wave: '10'
        spec:
          profile:
            - name: slave
              interface: $interface
              ptp4lOpts: '-2 -s'
              phc2sysOpts: '-a -r -n 24'
              ptpSchedulingPolicy: SCHED_FIFO
              ptpSchedulingPriority: 10
              ptpSettings:
                logReduce: 'true'
              ptp4lConf: |
                [global]
                #
                # Default Data Set
                #
                twoStepFlag 1
                slaveOnly 1
                priority1 128
                priority2 128
                domainNumber 24
                #utc_offset 37
                clockClass 255
                clockAccuracy 0xFE
                offsetScaledLogVariance 0xFFFF
                free_running 0
                freq_est_interval 1
                dscp_event 0
                dscp_general 0
                dataset_comparison G.8275.x
                G.8275.defaultDS.localPriority 128
                #
                # Port Data Set
                #
                logAnnounceInterval -3
                logSyncInterval -4
                logMinDelayReqInterval -4
                logMinPdelayReqInterval -4
                announceReceiptTimeout 3
                syncReceiptTimeout 0
                delayAsymmetry 0
                fault_reset_interval -4
                neighborPropDelayThresh 20000000
                masterOnly 0
                G.8275.portDS.localPriority 128
                #
                # Run time options
                #
                assume_two_step 0
```

```
logging_level 6
path_trace_enabled 0
follow_up_info 0
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 7
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
max_frequency 900000000
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type OC
network_transport L2
delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
egressLatency 0
ingressLatency 0
boundary_clock_jbod 0
```

```
              #
              # Clock description
              #
              productDescription ;;
              revisionData ;;
              manufacturerIdentity 00:00:00
              userDescription ;
              timeSource 0xA0
          recommend:
            - profile: slave
              priority: 4
              match:
                - nodeLabel: node-role.kubernetes.io/master
```

Using the source file **PtpConfigSlave.yaml** as an example, the file defines a **PtpConfig** CR. The generated policy for the **PtpConfigSlave** example is named **group-du-sno-config-policy**. The **PtpConfig** CR defined in the generated **group-du-sno-config-policy** is named **du-ptp-slave**. The **spec** defined in **PtpConfigSlave.yaml** is placed under **du-ptp-slave** along with the other **spec** items defined under the source file.

The following example shows the **group-du-sno-config-policy** CR:

```
---
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
    name: du-upgrade
placementBindingDefaults:
    name: du-upgrade-placement-binding
policyDefaults:
    namespace: ztp-group-du-sno
    placement:
        labelSelector:
            matchExpressions:
                - key: group-du-sno
                  operator: Exists
    remediationAction: inform
    severity: low
    namespaceSelector:
        exclude:
            - kube-*
        include:
            - '*'
    evaluationInterval:
        compliant: 10m
        noncompliant: 10s
policies:
    - name: du-upgrade-operator-catsrc-policy
      policyAnnotations:
        ran.openshift.io/ztp-deploy-wave: "1"
      manifests:
        - path: source-crs/DefaultCatsrc.yaml
          patches:
            - metadata:
                name: redhat-operators
              spec:
```

```
    displayName: Red Hat Operators Catalog
    image: registry.example.com:5000/olm/redhat-operators:v4.14
    updateStrategy:
      registryPoll:
        interval: 1h
  status:
    connectionState:
      lastObservedState: READY
```

9.1.3. Recommendations when customizing PolicyGenerator CRs

Consider the following best practices when customizing site configuration **PolicyGenerator** custom resources (CRs):

- Use as few policies as are necessary. Using fewer policies requires less resources. Each additional policy creates increased CPU load for the hub cluster and the deployed managed cluster. CRs are combined into policies based on the **policyName** field in the **PolicyGenerator** CR. CRs in the same **PolicyGenerator** which have the same value for **policyName** are managed under a single policy.
- In disconnected environments, use a single catalog source for all Operators by configuring the registry as a single index containing all Operators. Each additional **CatalogSource** CR on the managed clusters increases CPU usage.
- **MachineConfig** CRs should be included as **extraManifests** in the **SiteConfig** CR so that they are applied during installation. This can reduce the overall time taken until the cluster is ready to deploy applications.
- **PolicyGenerator** CRs should override the channel field to explicitly identify the desired version. This ensures that changes in the source CR during upgrades does not update the generated subscription.

Additional resources

- For recommendations about scaling clusters with RHACM, see Performance and scalability.

NOTE

When managing large numbers of spoke clusters on the hub cluster, minimize the number of policies to reduce resource consumption.

Grouping multiple configuration CRs into a single or limited number of policies is one way to reduce the overall number of policies on the hub cluster. When using the common, group, and site hierarchy of policies for managing site configuration, it is especially important to combine site-specific configuration into a single policy.

9.1.4. PolicyGenerator CRs for RAN deployments

Use **PolicyGenerator** custom resources (CRs) to customize the configuration applied to the cluster by using the GitOps Zero Touch Provisioning (ZTP) pipeline. The **PolicyGenerator** CR allows you to generate one or more policies to manage the set of configuration CRs on your fleet of clusters. The **PolicyGenerator** CR identifies the set of managed CRs, bundles them into policies, builds the policy wrapping around those CRs, and associates the policies with clusters by using label binding rules.

The reference configuration, obtained from the GitOps ZTP container, is designed to provide a set of critical features and node tuning settings that ensure the cluster can support the stringent performance and resource utilization constraints typical of RAN (Radio Access Network) Distributed Unit (DU) applications. Changes or omissions from the baseline configuration can affect feature availability, performance, and resource utilization. Use the reference **PolicyGenerator** CRs as the basis to create a hierarchy of configuration files tailored to your specific site requirements.

The baseline **PolicyGenerator** CRs that are defined for RAN DU cluster configuration can be extracted from the GitOps ZTP **ztp-site-generate** container. See "Preparing the GitOps ZTP site configuration repository" for further details.

The **PolicyGenerator** CRs can be found in the **./out/argocd/example/acmpolicygenerator/** folder. The reference architecture has common, group, and site-specific configuration CRs. Each **PolicyGenerator** CR refers to other CRs that can be found in the **./out/source-crs** folder.

The **PolicyGenerator** CRs relevant to RAN cluster configuration are described below. Variants are provided for the group **PolicyGenerator** CRs to account for differences in single-node, three-node compact, and standard cluster configurations. Similarly, site-specific configuration variants are provided for single-node clusters and multi-node (compact or standard) clusters. Use the group and site-specific configuration variants that are relevant for your deployment.

Table 9.2. PolicyGenerator CRs for RAN deployments

PolicyGenerator CR	Description
acm-example-multinode-site.yaml	Contains a set of CRs that get applied to multi-node clusters. These CRs configure SR-IOV features typical for RAN installations.
acm-example-sno-site.yaml	Contains a set of CRs that get applied to single-node OpenShift clusters. These CRs configure SR-IOV features typical for RAN installations.
acm-common-mno-ranGen.yaml	Contains a set of common RAN policy configuration that get applied to multi-node clusters.
acm-common-ranGen.yaml	Contains a set of common RAN CRs that get applied to all clusters. These CRs subscribe to a set of operators providing cluster features typical for RAN as well as baseline cluster tuning.
acm-group-du-3node-ranGen.yaml	Contains the RAN policies for three-node clusters only.
acm-group-du-sno-ranGen.yaml	Contains the RAN policies for single-node clusters only.
acm-group-du-standard-ranGen.yaml	Contains the RAN policies for standard three control-plane clusters.
acm-group-du-3node-validator-ranGen.yaml	**PolicyGenerator** CR used to generate the various policies required for three-node clusters.

PolicyGenerator CR	Description
acm-group-du-standard-validator-ranGen.yaml	**PolicyGenerator** CR used to generate the various policies required for standard clusters.
acm-group-du-sno-validator-ranGen.yaml	**PolicyGenerator** CR used to generate the various policies required for single-node OpenShift clusters.

Additional resources

- Preparing the GitOps ZTP site configuration repository

9.1.5. Customizing a managed cluster with PolicyGenerator CRs

Use the following procedure to customize the policies that get applied to the managed cluster that you provision using the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You configured the hub cluster for generating the required installation and policy CRs.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. Create a **PolicyGenerator** CR for site-specific configuration CRs.
   a. Choose the appropriate example for your CR from the **out/argocd/example/acmpolicygenerator/** folder, for example, **acm-example-sno-site.yaml** or **acm-example-multinode-site.yaml**.
   b. Change the **policyDefaults.placement.labelSelector** field in the example file to match the site-specific label included in the **SiteConfig** CR. In the example **SiteConfig** file, the site-specific label is **sites: example-sno**.

      NOTE

      Ensure that the labels defined in your **PolicyGenerator** **policyDefaults.placement.labelSelector** field correspond to the labels that are defined in the related managed clusters **SiteConfig** CR.

   c. Change the content in the example file to match the desired configuration.
2. Optional: Create a **PolicyGenerator** CR for any common configuration CRs that apply to the entire fleet of clusters.

   a. Select the appropriate example for your CR from the **out/argocd/example/acmpolicygenerator/** folder, for example, **acm-common-ranGen.yaml**.

   b. Change the content in the example file to match the required configuration.

3. Optional: Create a **PolicyGenerator** CR for any group configuration CRs that apply to the certain groups of clusters in the fleet.
   Ensure that the content of the overlaid spec files matches your required end state. As a reference, the **out/source-crs** directory contains the full list of source-crs available to be included and overlaid by your PolicyGenerator templates.

   NOTE

   Depending on the specific requirements of your clusters, you might need more than a single group policy per cluster type, especially considering that the example group policies each have a single **PerformancePolicy.yaml** file that can only be shared across a set of clusters if those clusters consist of identical hardware configurations.

   a. Select the appropriate example for your CR from the **out/argocd/example/acmpolicygenerator/** folder, for example, **acm-group-du-sno-ranGen.yaml**.

   b. Change the content in the example file to match the required configuration.

4. Optional. Create a validator inform policy **PolicyGenerator** CR to signal when the GitOps ZTP installation and configuration of the deployed cluster is complete. For more information, see "Creating a validator inform policy".

5. Define all the policy namespaces in a YAML file similar to the example **out/argocd/example/acmpolicygenerator//ns.yaml** file.

   IMPORTANT

   Do not include the **Namespace** CR in the same file with the **PolicyGenerator** CR.

6. Add the **PolicyGenerator** CRs and **Namespace** CR to the **kustomization.yaml** file in the generators section, similar to the example shown in **out/argocd/example/acmpolicygenerator/kustomization.yaml**.

7. Commit the **PolicyGenerator** CRs, **Namespace** CR, and associated **kustomization.yaml** file in your Git repository and push the changes.
   The ArgoCD pipeline detects the changes and begins the managed cluster deployment. You can push the changes to the **SiteConfig** CR and the **PolicyGenerator** CR simultaneously.

Additional resources

- Signalling GitOps ZTP cluster deployment completion with validator inform policies

9.1.6. Monitoring managed cluster policy deployment progress

The ArgoCD pipeline uses **PolicyGenerator** CRs in Git to generate the RHACM policies and then sync them to the hub cluster. You can monitor the progress of the managed cluster policy synchronization after the assisted service installs OpenShift Container Platform on the managed cluster.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. The Topology Aware Lifecycle Manager (TALM) applies the configuration policies that are bound to the cluster.
   After the cluster installation is complete and the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR corresponding to this cluster, with a list of ordered policies defined by the **ran.openshift.io/ztp-deploy-wave annotations**, is automatically created by the TALM. The cluster's policies are applied in the order listed in **ClusterGroupUpgrade** CR.

   You can monitor the high-level progress of configuration policy reconciliation by using the following commands:

   ```
   $ export CLUSTER=<clusterName>
   ```

   ```
   $ oc get clustergroupupgrades -n ztp-install $CLUSTER -o jsonpath='{.status.conditions[-1:]}'
   | jq
   ```

   #### Example output

   ```
   {
     "lastTransitionTime": "2022-11-09T07:28:09Z",
     "message": "Remediating non-compliant policies",
     "reason": "InProgress",
     "status": "True",
     "type": "Progressing"
   }
   ```

2. You can monitor the detailed cluster policy compliance status by using the RHACM dashboard or the command line.

   a. To check policy compliance by using **oc**, run the following command:

   ```
   $ oc get policies -n $CLUSTER
   ```

   #### Example output

   ```
   NAME                                                    REMEDIATION ACTION   COMPLIANCE STATE
   AGE
   ztp-common.common-config-policy                         inform               Compliant
   3h42m
   ztp-common.common-subscriptions-policy                  inform               NonCompliant
   3h42m
   ztp-group.group-du-sno-config-policy                    inform               NonCompliant
   3h42m
   ```

```
ztp-group.group-du-sno-validator-du-policy          inform        NonCompliant
3h42m
ztp-install.example1-common-config-policy-pjz9s      enforce       Compliant
167m
ztp-install.example1-common-subscriptions-policy-zzd9k   enforce      NonCompliant
164m
ztp-site.example1-config-policy                 inform        NonCompliant    3h42m
ztp-site.example1-perf-policy                   inform        NonCompliant    3h42m
```

b. To check policy status from the RHACM web console, perform the following actions:

    i. Click **Governance** → **Find policies**.

    ii. Click on a cluster policy to check its status.

When all of the cluster policies become compliant, GitOps ZTP installation and configuration for the cluster is complete. The **ztp-done** label is added to the cluster.

In the reference configuration, the final policy that becomes compliant is the one defined in the ***-du-validator-policy** policy. This policy, when compliant on a cluster, ensures that all cluster configuration, Operator installation, and Operator configuration is complete.

9.1.7. Validating the generation of configuration policy CRs

Policy custom resources (CRs) are generated in the same namespace as the **PolicyGenerator** from which they are created. The same troubleshooting flow applies to all policy CRs generated from a **PolicyGenerator** regardless of whether they are **ztp-common**, **ztp-group**, or **ztp-site** based, as shown using the following commands:

```
$ export NS=<namespace>
```

```
$ oc get policy -n $NS
```

The expected set of policy-wrapped CRs should be displayed.

If the policies failed synchronization, use the following troubleshooting steps.

Procedure

1. To display detailed information about the policies, run the following command:

   ```
   $ oc describe -n openshift-gitops application policies
   ```

2. Check for **Status: Conditions:** to show the error logs. For example, setting an invalid **sourceFile** entry to **fileName:** generates the error shown below:

   ```
   Status:
     Conditions:
       Last Transition Time:  2021-11-26T17:21:39Z
       Message:              rpc error: code = Unknown desc = `kustomize build
   /tmp/https___git.com/ran-sites/policies/ --enable-alpha-plugins` failed exit status 1:
   2021/11/26 17:21:40 Error could not find test.yaml under source-crs/: no such file or directory
   ```

```
Error: failure in plugin configured via /tmp/kust-plugin-config-52463179; exit status 1: exit
status 1
    Type:  ComparisonError
```

3. Check for **Status: Sync:**. If there are log errors at **Status: Conditions:**, the **Status: Sync:** shows **Unknown** or **Error**:

```
Status:
  Sync:
    Compared To:
      Destination:
        Namespace:  policies-sub
        Server:     https://kubernetes.default.svc
      Source:
        Path:              policies
        Repo URL:          https://git.com/ran-sites/policies/.git
        Target Revision:  master
    Status:                Error
```

4. When Red Hat Advanced Cluster Management (RHACM) recognizes that policies apply to a **ManagedCluster** object, the policy CR objects are applied to the cluster namespace. Check to see if the policies were copied to the cluster namespace:

```
$ oc get policy -n $CLUSTER
```

Example output:

```
NAME                                         REMEDIATION ACTION   COMPLIANCE STATE   AGE
ztp-common.common-config-policy              inform               Compliant          13d
ztp-common.common-subscriptions-policy       inform               Compliant          13d
ztp-group.group-du-sno-config-policy         inform               Compliant          13d
ztp-group.group-du-sno-validator-du-policy   inform               Compliant          13d
ztp-site.example-sno-config-policy           inform               Compliant          13d
```

RHACM copies all applicable policies into the cluster namespace. The copied policy names have the format: **<PolicyGenerator.Namespace>.<PolicyGenerator.Name>-<policyName>**.

5. Check the placement rule for any policies not copied to the cluster namespace. The **matchSelector** in the **Placement** for those policies should match labels on the **ManagedCluster** object:

```
$ oc get Placement -n $NS
```

6. Note the **Placement** name appropriate for the missing policy, common, group, or site, using the following command:

```
$ oc get Placement -n $NS <placement_rule_name> -o yaml
```

- The status-decisions should include your cluster name.
- The key-value pair of the **matchSelector** in the spec must match the labels on your managed cluster.

7. Check the labels on the **ManagedCluster** object by using the following command:

```
$ oc get ManagedCluster $CLUSTER -o jsonpath='{.metadata.labels}' | jq
```

8. Check to see what policies are compliant by using the following command:

   ```
   $ oc get policy -n $CLUSTER
   ```

   If the **Namespace**, **OperatorGroup**, and **Subscription** policies are compliant but the Operator configuration policies are not, it is likely that the Operators did not install on the managed cluster. This causes the Operator configuration policies to fail to apply because the CRD is not yet applied to the spoke.

9.1.8. Restarting policy reconciliation

You can restart policy reconciliation when unexpected compliance issues occur, for example, when the **ClusterGroupUpgrade** custom resource (CR) has timed out.

Procedure

1. A **ClusterGroupUpgrade** CR is generated in the namespace **ztp-install** by the Topology Aware Lifecycle Manager after the managed cluster becomes **Ready**:

   ```
   $ export CLUSTER=<clusterName>
   ```

   ```
   $ oc get clustergroupupgrades -n ztp-install $CLUSTER
   ```

2. If there are unexpected issues and the policies fail to become complaint within the configured timeout (the default is 4 hours), the status of the **ClusterGroupUpgrade** CR shows **UpgradeTimedOut**:

   ```
   $ oc get clustergroupupgrades -n ztp-install $CLUSTER -o jsonpath='{.status.conditions[?(@.type=="Ready")]}'
   ```

3. A **ClusterGroupUpgrade** CR in the **UpgradeTimedOut** state automatically restarts its policy reconciliation every hour. If you have changed your policies, you can start a retry immediately by deleting the existing **ClusterGroupUpgrade** CR. This triggers the automatic creation of a new **ClusterGroupUpgrade** CR that begins reconciling the policies immediately:

   ```
   $ oc delete clustergroupupgrades -n ztp-install $CLUSTER
   ```

Note that when the **ClusterGroupUpgrade** CR completes with status **UpgradeCompleted** and the managed cluster has the label **ztp-done** applied, you can make additional configuration changes by using **PolicyGenerator**. Deleting the existing **ClusterGroupUpgrade** CR will not make the TALM generate a new CR.

At this point, GitOps ZTP has completed its interaction with the cluster and any further interactions should be treated as an update and a new **ClusterGroupUpgrade** CR created for remediation of the policies.

Additional resources

- For information about using Topology Aware Lifecycle Manager (TALM) to construct your own **ClusterGroupUpgrade** CR, see About the ClusterGroupUpgrade CR.

9.1.9. Changing applied managed cluster CRs using policies

You can remove content from a custom resource (CR) that is deployed in a managed cluster through a policy.

By default, all **Policy** CRs created from a **PolicyGenerator** CR have the **complianceType** field set to **musthave**. A **musthave** policy without the removed content is still compliant because the CR on the managed cluster has all the specified content. With this configuration, when you remove content from a CR, TALM removes the content from the policy but the content is not removed from the CR on the managed cluster.

With the **complianceType** field to **mustonlyhave**, the policy ensures that the CR on the cluster is an exact match of what is specified in the policy.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have deployed a managed cluster from a hub cluster running RHACM.
- You have installed Topology Aware Lifecycle Manager on the hub cluster.

Procedure

1. Remove the content that you no longer need from the affected CRs. In this example, the **disableDrain: false** line was removed from the **SriovOperatorConfig** CR.

   Example CR

   ```
   apiVersion: sriovnetwork.openshift.io/v1
   kind: SriovOperatorConfig
   metadata:
     name: default
     namespace: openshift-sriov-network-operator
   spec:
     configDaemonNodeSelector:
       "node-role.kubernetes.io/$mcp": ""
     disableDrain: true
     enableInjector: true
     enableOperatorWebhook: true
   ```

2. Change the **complianceType** of the affected policies to **mustonlyhave** in the **acm-group-du-sno-ranGen.yaml** file.

   Example YAML

   ```
   # ...
   policyDefaults:
     complianceType: "mustonlyhave"
   # ...
   policies:
     - name: config-policy
       policyAnnotations:
   ```

```
      ran.openshift.io/ztp-deploy-wave: ""
    manifests:
      - path: source-crs/SriovOperatorConfig.yaml
```

3. Create a **ClusterGroupUpdates** CR and specify the clusters that must receive the CR changes::

Example ClusterGroupUpdates CR

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-remove
  namespace: default
spec:
  managedPolicies:
    - ztp-group.group-du-sno-config-policy
  enable: false
  clusters:
  - spoke1
  - spoke2
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
  batchTimeoutAction:
```

4. Create the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc create -f cgu-remove.yaml
```

5. When you are ready to apply the changes, for example, during an appropriate maintenance window, change the value of the **spec.enable** field to **true** by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-remove \
--patch '{"spec":{"enable":true}}' --type=merge
```

Verification

1. Check the status of the policies by running the following command:

```
$ oc get <kind> <changed_cr_name>
```

Example output

```
NAMESPACE   NAME                                                   REMEDIATION ACTION
COMPLIANCE STATE   AGE
default     cgu-ztp-group.group-du-sno-config-policy          enforce                          17m
default     ztp-group.group-du-sno-config-policy             inform           NonCompliant
15h
```

When the **COMPLIANCE STATE** of the policy is **Compliant**, it means that the CR is updated and the unwanted content is removed.

2. Check that the policies are removed from the targeted clusters by running the following command on the managed clusters:

```
$ oc get <kind> <changed_cr_name>
```

   If there are no results, the CR is removed from the managed cluster.

9.1.10. Indication of done for GitOps ZTP installations

GitOps Zero Touch Provisioning (ZTP) simplifies the process of checking the GitOps ZTP installation status for a cluster. The GitOps ZTP status moves through three phases: cluster installation, cluster configuration, and GitOps ZTP done.

Cluster installation phase

The cluster installation phase is shown by the **ManagedClusterJoined** and **ManagedClusterAvailable** conditions in the **ManagedCluster** CR . If the **ManagedCluster** CR does not have these conditions, or the condition is set to **False**, the cluster is still in the installation phase. Additional details about installation are available from the **AgentClusterInstall** and **ClusterDeployment** CRs. For more information, see "Troubleshooting GitOps ZTP".

Cluster configuration phase

The cluster configuration phase is shown by a **ztp-running** label applied the **ManagedCluster** CR for the cluster.

GitOps ZTP done

Cluster installation and configuration is complete in the GitOps ZTP done phase. This is shown by the removal of the **ztp-running** label and addition of the **ztp-done** label to the **ManagedCluster** CR.
The **ztp-done** label shows that the configuration has been applied and the baseline DU configuration has completed cluster tuning.
The change to the GitOps ZTP done state is conditional on the compliant state of a Red Hat Advanced Cluster Management (RHACM) validator inform policy. This policy captures the existing criteria for a completed installation and validates that it moves to a compliant state only when GitOps ZTP provisioning of the managed cluster is complete.

The validator inform policy ensures the configuration of the cluster is fully applied and Operators have completed their initialization. The policy validates the following:

- The target **MachineConfigPool** contains the expected entries and has finished updating. All nodes are available and not degraded.
- The SR-IOV Operator has completed initialization as indicated by at least one **SriovNetworkNodeState** with **syncStatus: Succeeded**.
- The PTP Operator daemon set exists.

9.2. ADVANCED MANAGED CLUSTER CONFIGURATION WITH POLICYGENERATOR RESOURCES

You can use **PolicyGenerator** CRs to deploy custom functionality in your managed clusters.

IMPORTANT

Using PolicyGenerator resources with GitOps ZTP is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

NOTE

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

9.2.1. Deploying additional changes to clusters

If you require cluster configuration changes outside of the base GitOps Zero Touch Provisioning (ZTP) pipeline configuration, there are three options:

Apply the additional configuration after the GitOps ZTP pipeline is complete

When the GitOps ZTP pipeline deployment is complete, the deployed cluster is ready for application workloads. At this point, you can install additional Operators and apply configurations specific to your requirements. Ensure that additional configurations do not negatively affect the performance of the platform or allocated CPU budget.

Add content to the GitOps ZTP library

The base source custom resources (CRs) that you deploy with the GitOps ZTP pipeline can be augmented with custom content as required.

Create extra manifests for the cluster installation

Extra manifests are applied during installation and make the installation process more efficient.

IMPORTANT

Providing additional source CRs or modifying existing source CRs can significantly impact the performance or CPU profile of OpenShift Container Platform.

Additional resources

- Customizing extra installation manifests in the GitOps ZTP pipeline

9.2.2. Using PolicyGenerator CRs to override source CRs content

PolicyGenerator custom resources (CRs) allow you to overlay additional configuration details on top of the base source CRs provided with the GitOps plugin in the **ztp-site-generate** container. You can think of **PolicyGenerator** CRs as a logical merge or patch to the base CR. Use **PolicyGenerator** CRs to update a single field of the base CR, or overlay the entire contents of the base CR. You can update values and insert fields that are not in the base CR.

The following example procedure describes how to update fields in the generated **PerformanceProfile** CR for the reference configuration based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml** file. Use the procedure as a basis for modifying other parts of the **PolicyGenerator** based on your requirements.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for Argo CD.

Procedure

1. Review the baseline source CR for existing content. You can review the source CRs listed in the reference **PolicyGenerator** CRs by extracting them from the GitOps Zero Touch Provisioning (ZTP) container.

   a. Create an /**out** folder:

   ```
   $ mkdir -p ./out
   ```

   b. Extract the source CRs:

   ```
   $ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16.1 extract /home/ztp --tar | tar x -C ./out
   ```

2. Review the baseline **PerformanceProfile** CR in **./out/source-crs/PerformanceProfile.yaml**:

```
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: $name
  annotations:
    ran.openshift.io/ztp-deploy-wave: "10"
spec:
  additionalKernelArgs:
  - "idle=poll"
  - "rcupdate.rcu_normal_after_boot=0"
  cpu:
    isolated: $isolated
    reserved: $reserved
  hugepages:
    defaultHugepagesSize: $defaultHugepagesSize
    pages:
      - size: $size
        count: $count
        node: $node
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/$mcp: ""
  net:
    userLevelNetworking: true
  nodeSelector:
    node-role.kubernetes.io/$mcp: ''
  numa:
    topologyPolicy: "restricted"
  realTimeKernel:
    enabled: true
```

NOTE

Any fields in the source CR which contain **$...** are removed from the generated CR if they are not provided in the **PolicyGenerator** CR.

3. Update the **PolicyGenerator** entry for **PerformanceProfile** in the **acm-group-du-sno-ranGen.yaml** reference file. The following example **PolicyGenerator** CR stanza supplies appropriate CPU specifications, sets the **hugepages** configuration, and adds a new field that sets **globallyDisableIrqLoadBalancing** to false.

```
- path: source-crs/PerformanceProfile.yaml
  patches:
    - spec:
        # These must be tailored for the specific hardware platform
        cpu:
          isolated: "2-19,22-39"
          reserved: "0-1,20-21"
        hugepages:
          defaultHugepagesSize: 1G
          pages:
          - size: 1G
            count: 10
        globallyDisableIrqLoadBalancing: false
```

4. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP argo CD application.

Example output

The GitOps ZTP application generates an RHACM policy that contains the generated **PerformanceProfile** CR. The contents of that CR are derived by merging the **metadata** and **spec** contents from the **PerformanceProfile** entry in the **PolicyGenerator** onto the source CR. The resulting CR has the following content:

```
---
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
    name: openshift-node-performance-profile
spec:
    additionalKernelArgs:
        - idle=poll
        - rcupdate.rcu_normal_after_boot=0
    cpu:
        isolated: 2-19,22-39
        reserved: 0-1,20-21
    globallyDisableIrqLoadBalancing: false
    hugepages:
        defaultHugepagesSize: 1G
        pages:
            - count: 10
              size: 1G
    machineConfigPoolSelector:
        pools.operator.machineconfiguration.openshift.io/master: ""
    net:
        userLevelNetworking: true
```

```
nodeSelector:
  node-role.kubernetes.io/master: ""
numa:
  topologyPolicy: restricted
realTimeKernel:
  enabled: true
```

NOTE

In the /**source-crs** folder that you extract from the **ztp-site-generate** container, the **$** syntax is not used for template substitution as implied by the syntax. Rather, if the **policyGen** tool sees the **$** prefix for a string and you do not specify a value for that field in the related **PolicyGenerator** CR, the field is omitted from the output CR entirely.

An exception to this is the **$mcp** variable in /**source-crs** YAML files that is substituted with the specified value for **mcp** from the **PolicyGenerator** CR. For example, in **example/policygentemplates/acm-group-du-standard-ranGen.yaml**, the value for **mcp** is **worker**:

```
spec:
 bindingRules:
  group-du-standard: ""
 mcp: "worker"
```

The **policyGen** tool replace instances of **$mcp** with **worker** in the output CRs.

9.2.3. Adding custom content to the GitOps ZTP pipeline

Perform the following procedure to add new content to the GitOps ZTP pipeline.

Procedure

1. Create a subdirectory named **source-crs** in the directory that contains the **kustomization.yaml** file for the **PolicyGenerator** custom resource (CR).

2. Add your user-provided CRs to the **source-crs** subdirectory, as shown in the following example:

```
example
└── acmpolicygenerator
    ├── dev.yaml
    ├── kustomization.yaml
    ├── mec-edge-sno1.yaml
    ├── sno.yaml
    └── source-crs 1
        ├── PaoCatalogSource.yaml
        ├── PaoSubscription.yaml
        ├── custom-crs
        |   ├── apiserver-config.yaml
        |   └── disable-nic-lldp.yaml
        └── elasticsearch
            ├── ElasticsearchNS.yaml
            └── ElasticsearchOperatorGroup.yaml
```

1. The **source-crs** subdirectory must be in the same directory as the **kustomization.yaml** file.

3. Update the required **PolicyGenerator** CRs to include references to the content you added in the **source-crs/custom-crs** and **source-crs/elasticsearch** directories. For example:

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: group-dev
placementBindingDefaults:
  name: group-dev-placement-binding
policyDefaults:
  namespace: ztp-clusters
  placement:
    labelSelector:
      matchExpressions:
        - key: dev
          operator: In
          values:
           - "true"
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: group-dev-group-dev-cluster-log-ns
   policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
   manifests:
    - path: source-crs/ClusterLogNS.yaml
  - name: group-dev-group-dev-cluster-log-operator-group
   policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
   manifests:
    - path: source-crs/ClusterLogOperGroup.yaml
  - name: group-dev-group-dev-cluster-log-sub
   policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
   manifests:
    - path: source-crs/ClusterLogSubscription.yaml
  - name: group-dev-group-dev-lso-ns
   policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
   manifests:
    - path: source-crs/StorageNS.yaml
  - name: group-dev-group-dev-lso-operator-group
   policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/StorageOperGroup.yaml
  - name: group-dev-group-dev-lso-sub
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/StorageSubscription.yaml
  - name: group-dev-group-dev-pao-cat-source
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "1"
    manifests:
      - path: source-crs/PaoSubscriptionCatalogSource.yaml
        patches:
          - spec:
              image: <container_image_url>
  - name: group-dev-group-dev-pao-ns
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/PaoSubscriptionNS.yaml
  - name: group-dev-group-dev-pao-sub
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/PaoSubscription.yaml
  - name: group-dev-group-dev-elasticsearch-ns
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: elasticsearch/ElasticsearchNS.yaml (1)
  - name: group-dev-group-dev-elasticsearch-operator-group
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: elasticsearch/ElasticsearchOperatorGroup.yaml
  - name: group-dev-group-dev-apiserver-config
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: custom-crs/apiserver-config.yaml (2)
  - name: group-dev-group-dev-disable-nic-lldp
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: custom-crs/disable-nic-lldp.yaml
```

1 2 Set **policies.manifests.path** to include the relative path to the file from the **/source-crs** parent directory.

4. Commit the **PolicyGenerator** change in Git, and then push to the Git repository that is monitored by the GitOps ZTP Argo CD policies application.

5. Update the **ClusterGroupUpgrade** CR to include the changed **PolicyGenerator** and save it as **cgu-test.yaml**. The following example shows a generated **cgu-test.yaml** file.

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: custom-source-cr
  namespace: ztp-clusters
spec:
  managedPolicies:
    - group-dev-config-policy
  enable: true
  clusters:
  - cluster1
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
```

6. Apply the updated **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f cgu-test.yaml
```

Verification

- Check that the updates have succeeded by running the following command:

```
$ oc get cgu -A
```

Example output

```
NAMESPACE     NAME              AGE   STATE        DETAILS
ztp-clusters  custom-source-cr  6s    InProgress   Remediating non-compliant policies
ztp-install   cluster1          19h   Completed    All clusters are compliant with all the managed
policies
```

9.2.4. Configuring policy compliance evaluation timeouts for PolicyGenerator CRs

Use Red Hat Advanced Cluster Management (RHACM) installed on a hub cluster to monitor and report on whether your managed clusters are compliant with applied policies. RHACM uses policy templates to apply predefined policy controllers and policies. Policy controllers are Kubernetes custom resource definition (CRD) instances.

You can override the default policy evaluation intervals with **PolicyGenerator** custom resources (CRs). You configure duration settings that define how long a **ConfigurationPolicy** CR can be in a state of policy compliance or non-compliance before RHACM re-evaluates the applied cluster policies.

The GitOps Zero Touch Provisioning (ZTP) policy generator generates **ConfigurationPolicy** CR policies with pre-defined policy evaluation intervals. The default value for the **noncompliant** state is 10 seconds. The default value for the **compliant** state is 10 minutes. To disable the evaluation interval, set the value to **never**.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. To configure the evaluation interval for all policies in a **PolicyGenerator** CR, set appropriate **compliant** and **noncompliant** values for the **evaluationInterval** field. For example:

```
policyDefaults:
  evaluationInterval:
    compliant: 30m
    noncompliant: 45s
```

NOTE

You can also set **compliant** and **noncompliant** fields to **never** to stop evaluating the policy after it reaches particular compliance state.

2. To configure the evaluation interval for an individual policy object in a **PolicyGenerator** CR, add the **evaluationInterval** field and set appropriate values. For example:

```
policies:
  - name: "sriov-sub-policy"
    manifests:
      - path: "SriovSubscription.yaml"
        evaluationInterval:
          compliant: never
          noncompliant: 10s
```

3. Commit the **PolicyGenerator** CRs files in the Git repository and push your changes.

Verification

Check that the managed spoke cluster policies are monitored at the expected intervals.

1. Log in as a user with **cluster-admin** privileges on the managed cluster.

2. Get the pods that are running in the **open-cluster-management-agent-addon** namespace. Run the following command:

```
$ oc get pods -n open-cluster-management-agent-addon
```

Example output

```
NAME                                      READY   STATUS    RESTARTS         AGE
config-policy-controller-858b894c68-v4xdb    1/1     Running   22 (5d8h ago)   10d
```

3. Check the applied policies are being evaluated at the expected interval in the logs for the **config-policy-controller** pod:

```
$ oc logs -n open-cluster-management-agent-addon config-policy-controller-858b894c68-
v4xdb
```

Example output

```
2022-05-10T15:10:25.280Z	info	configuration-policy-controller
controllers/configurationpolicy_controller.go:166	Skipping the policy evaluation due to the
policy not reaching the evaluation interval  {"policy": "compute-1-config-policy-config"}
2022-05-10T15:10:25.280Z	info	configuration-policy-controller
controllers/configurationpolicy_controller.go:166	Skipping the policy evaluation due to the
policy not reaching the evaluation interval  {"policy": "compute-1-common-compute-1-catalog-
policy-config"}
```

9.2.5. Signalling GitOps ZTP cluster deployment completion with validator inform policies

Create a validator inform policy that signals when the GitOps Zero Touch Provisioning (ZTP) installation and configuration of the deployed cluster is complete. This policy can be used for deployments of single-node OpenShift clusters, three-node clusters, and standard clusters.

Procedure

1. Create a standalone **PolicyGenerator** custom resource (CR) that contains the source file **validatorCRs/informDuValidator.yaml**. You only need one standalone **PolicyGenerator** CR for each cluster type. For example, this CR applies a validator inform policy for single-node OpenShift clusters:

   Example single-node cluster validator inform policy CR (acm-group-du-sno-validator-ranGen.yaml)

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: group-du-sno-validator-latest
placementBindingDefaults:
  name: group-du-sno-validator-latest-placement-binding
policyDefaults:
  namespace: ztp-group
  placement:
    labelSelector:
      matchExpressions:
        - key: du-profile
          operator: In
          values:
            - latest
        - key: group-du-sno
          operator: Exists
        - key: ztp-done
          operator: DoesNotExist
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
```

```
policies:
  - name: group-du-sno-validator-latest-du-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "10000"
    evaluationInterval:
      compliant: 5s
    manifests:
      - path: source-crs/validatorCRs/informDuValidator-MCP-master.yaml
```

2. Commit the **PolicyGenerator** CR file in your Git repository and push the changes.

Additional resources

- Upgrading GitOps ZTP

9.2.6. Configuring power states using PolicyGenerator CRs

For low latency and high-performance edge deployments, it is necessary to disable or limit C-states and P-states. With this configuration, the CPU runs at a constant frequency, which is typically the maximum turbo frequency. This ensures that the CPU is always running at its maximum speed, which results in high performance and low latency. This leads to the best latency for workloads. However, this also leads to the highest power consumption, which might not be necessary for all workloads.

Workloads can be classified as critical or non-critical, with critical workloads requiring disabled C-state and P-state settings for high performance and low latency, while non-critical workloads use C-state and P-state settings for power savings at the expense of some latency and performance. You can configure the following three power states using GitOps Zero Touch Provisioning (ZTP):

- High-performance mode provides ultra low latency at the highest power consumption.
- Performance mode provides low latency at a relatively high power consumption.
- Power saving balances reduced power consumption with increased latency.

The default configuration is for a low latency, performance mode.

PolicyGenerator custom resources (CRs) allow you to overlay additional configuration details onto the base source CRs provided with the GitOps plugin in the **ztp-site-generate** container.

Configure the power states by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml**.

The following common prerequisites apply to configuring all three power states.

Prerequisites

- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for Argo CD.
- You have followed the procedure described in "Preparing the GitOps ZTP site configuration repository".

Additional resources

- Configuring node power consumption and realtime processing with workload hints

9.2.6.1. Configuring performance mode using PolicyGenerator CRs

Follow this example to set performance mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml**.

Performance mode provides low latency at a relatively high power consumption.

Prerequisites

- You have configured the BIOS with performance related settings by following the guidance in "Configuring host firmware for low latency and high performance".

Procedure

1. Update the **PolicyGenerator** entry for **PerformanceProfile** in the **acm-group-du-sno-ranGen.yaml** reference file in **out/argocd/example/acmpolicygenerator//** as follows to set performance mode.

```
- path: source-crs/PerformanceProfile.yaml
  patches:
    - spec:
        workloadHints:
            realTime: true
            highPowerConsumption: false
            perPodPowerManagement: false
```

2. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

9.2.6.2. Configuring high-performance mode using PolicyGenerator CRs

Follow this example to set high performance mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml**.

High performance mode provides ultra low latency at the highest power consumption.

Prerequisites

- You have configured the BIOS with performance related settings by following the guidance in "Configuring host firmware for low latency and high performance".

Procedure

1. Update the **PolicyGenerator** entry for **PerformanceProfile** in the **acm-group-du-sno-ranGen.yaml** reference file in **out/argocd/example/acmpolicygenerator/** as follows to set high-performance mode.

```
- path: source-crs/PerformanceProfile.yaml
  patches:
    - spec:
        workloadHints:
          realTime: true
          highPowerConsumption: true
          perPodPowerManagement: false
```

2. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

9.2.6.3. Configuring power saving mode using PolicyGenerator CRs

Follow this example to set power saving mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenerator** CR in the **acm-group-du-sno-ranGen.yaml**.

The power saving mode balances reduced power consumption with increased latency.

Prerequisites

- You enabled C-states and OS-controlled P-states in the BIOS.

Procedure

1. Update the **PolicyGenerator** entry for **PerformanceProfile** in the **acm-group-du-sno-ranGen.yaml** reference file in **out/argocd/example/acmpolicygenerator/** as follows to configure power saving mode. It is recommended to configure the CPU governor for the power saving mode through the additional kernel arguments object.

```
- path: source-crs/PerformanceProfile.yaml
  patches:
    - spec:
        # ...
        workloadHints:
          realTime: true
          highPowerConsumption: false
          perPodPowerManagement: true
        # ...
        additionalKernelArgs:
          - # ...
          - "cpufreq.default_governor=schedutil" (1)
```

(1) The **schedutil** governor is recommended, however, you can also use other governors, including **ondemand** and **powersave**.

2. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

Verification

1. Select a worker node in your deployed cluster from the list of nodes identified by using the following command:

```
$ oc get nodes
```

2. Log in to the node by using the following command:

   ```
   $ oc debug node/<node-name>
   ```

   Replace **<node-name>** with the name of the node you want to verify the power state on.

3. Set /**host** as the root directory within the debug shell. The debug pod mounts the host's root file system in /**host** within the pod. By changing the root directory to /**host**, you can run binaries contained in the host's executable paths as shown in the following example:

   ```
   # chroot /host
   ```

4. Run the following command to verify the applied power state:

   ```
   # cat /proc/cmdline
   ```

Expected output

- For power saving mode the **intel_pstate=passive**.

Additional resources

- Configuring power saving for nodes that run colocated high and low priority workloads
- Configuring host firmware for low latency and high performance
- Preparing the GitOps ZTP site configuration repository

9.2.6.4. Maximizing power savings

Limiting the maximum CPU frequency is recommended to achieve maximum power savings. Enabling C-states on the non-critical workload CPUs without restricting the maximum CPU frequency negates much of the power savings by boosting the frequency of the critical CPUs.

Maximize power savings by updating the **sysfs** plugin fields, setting an appropriate value for **max_perf_pct** in the **TunedPerformancePatch** CR for the reference configuration. This example based on the **acm-group-du-sno-ranGen.yaml** describes the procedure to follow to restrict the maximum CPU frequency.

Prerequisites

- You have configured power savings mode as described in "Using PolicyGenerator CRs to configure power savings mode".

Procedure

1. Update the **PolicyGenerator** entry for **TunedPerformancePatch** in the **acm-group-du-sno-ranGen.yaml** reference file in **out/argocd/example/acmpolicygenerator/**. To maximize power savings, add **max_perf_pct** as shown in the following example:

   ```
   - path: source-crs/TunedPerformancePatch.yaml
     patches:
       - spec:
         profile:
   ```

```
    - name: performance-patch
      data: |
        # ...
        [sysfs]
        /sys/devices/system/cpu/intel_pstate/max_perf_pct=<x> (1)
```

(1) The **max_perf_pct** controls the maximum frequency the **cpufreq** driver is allowed to set as a percentage of the maximum supported CPU frequency. This value applies to all CPUs. You can check the maximum supported frequency in **/sys/devices/system/cpu/cpu0/cpufreq/cpuinfo_max_freq**. As a starting point, you can use a percentage that caps all CPUs at the **All Cores Turbo** frequency. The **All Cores Turbo** frequency is the frequency that all cores run at when the cores are all fully occupied.

NOTE

To maximize power savings, set a lower value. Setting a lower value for **max_perf_pct** limits the maximum CPU frequency, thereby reducing power consumption, but also potentially impacting performance. Experiment with different values and monitor the system's performance and power consumption to find the optimal setting for your use-case.

2. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

9.2.7. Configuring LVM Storage using PolicyGenerator CRs

You can configure Logical Volume Manager (LVM) Storage for managed clusters that you deploy with GitOps Zero Touch Provisioning (ZTP).

NOTE

You use LVM Storage to persist event subscriptions when you use PTP events or bare-metal hardware events with HTTP transport.

Use the Local Storage Operator for persistent storage that uses local volumes in distributed units.

Prerequisites

- Install the OpenShift CLI (**oc**).
- Log in as a user with **cluster-admin** privileges.
- Create a Git repository where you manage your custom site configuration data.

Procedure

1. To configure LVM Storage for new managed clusters, add the following YAML to **policies.manifests** in the **acm-common-ranGen.yaml** file:

```
- name: subscription-policies
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
```

```
manifests:
  - path: source-crs/StorageLVMOSubscriptionNS.yaml
  - path: source-crs/StorageLVMOSubscriptionOperGroup.yaml
  - path: source-crs/StorageLVMOSubscription.yaml
    spec:
      name: lvms-operator
      channel: stable-4.16
```

NOTE

The Storage LVMO subscription is deprecated. In future releases of OpenShift Container Platform, the storage LVMO subscription will not be available. Instead, you must use the Storage LVMS subscription.

In OpenShift Container Platform 4.16, you can use the Storage LVMS subscription instead of the LVMO subscription. The LVMS subscription does not require manual overrides in the **acm-common-ranGen.yaml** file. Add the following YAML to **policies.manifests** in the **acm-common-ranGen.yaml** file to use the Storage LVMS subscription:

```
- path: source-crs/StorageLVMSubscriptionNS.yaml
- path: source-crs/StorageLVMSubscriptionOperGroup.yaml
- path: source-crs/StorageLVMSubscription.yaml
```

2. Add the **LVMCluster** CR to **policies.manifests** in your specific group or individual site configuration file. For example, in the **acm-group-du-sno-ranGen.yaml** file, add the following:

```
- fileName: StorageLVMCluster.yaml
  policyName: "lvms-config"
    metadata:
      name: "lvms-storage-cluster-config"
        spec:
          storage:
            deviceClasses:
            - name: vg1
              thinPoolConfig:
                name: thin-pool-1
                sizePercent: 90
                overprovisionRatio: 10
```

This example configuration creates a volume group (**vg1**) with all the available devices, except the disk where OpenShift Container Platform is installed. A thin-pool logical volume is also created.

3. Merge any other required changes and files with your custom site repository.

4. Commit the **PolicyGenerator** changes in Git, and then push the changes to your site configuration repository to deploy LVM Storage to new sites using GitOps ZTP.

9.2.8. Configuring PTP events with PolicyGenerator CRs

You can use the GitOps ZTP pipeline to configure PTP events that use HTTP or AMQP transport.

NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, Red Hat AMQ Interconnect support status.

9.2.8.1. Configuring PTP events that use HTTP transport

You can configure PTP events that use HTTP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. Apply the following **PolicyGenerator** changes to **acm-group-du-3node-ranGen.yaml**, **acm-group-du-sno-ranGen.yaml**, or **acm-group-du-standard-ranGen.yaml** files according to your requirements:

   a. In **policies.manifests**, add the **PtpOperatorConfig** CR file that configures the transport host:

```
- path: source-crs/PtpOperatorConfigForEvent.yaml
  patches:
  - metadata:
      name: default
      namespace: openshift-ptp
      annotations:
        ran.openshift.io/ztp-deploy-wave: "10"
    spec:
      daemonNodeSelector:
        node-role.kubernetes.io/$mcp: ""
      ptpEventConfig:
        enableEventPublisher: true
        transportHost: "http://ptp-event-publisher-service-NODE_NAME.openshift-
ptp.svc.cluster.local:9043"
```

   NOTE

   In OpenShift Container Platform 4.13 or later, you do not need to set the **transportHost** field in the **PtpOperatorConfig** resource when you use HTTP transport with PTP events.

   b. Configure the **linuxptp** and **phc2sys** for the PTP clock type and interface. For example, add the following YAML into **policies.manifests**:

```
- path: source-crs/PtpConfigSlave.yaml 1
  patches:
  - metadata:
      name: "du-ptp-slave"
    spec:
      recommend:
      - match:
        - nodeLabel: node-role.kubernetes.io/master
        priority: 4
        profile: slave
      profile:
      - name: "slave"
        # This interface must match the hardware in this group
        interface: "ens5f0" 2
        ptp4lOpts: "-2 -s --summary_interval -4" 3
        phc2sysOpts: "-a -r -n 24" 4
        ptpSchedulingPolicy: SCHED_FIFO
        ptpSchedulingPriority: 10
        ptpSettings:
          logReduce: "true"
        ptp4lConf: |
          [global]
          #
          # Default Data Set
          #
          twoStepFlag 1
          slaveOnly 1
          priority1 128
          priority2 128
          domainNumber 24
          #utc_offset 37
          clockClass 255
          clockAccuracy 0xFE
          offsetScaledLogVariance 0xFFFF
          free_running 0
          freq_est_interval 1
          dscp_event 0
          dscp_general 0
          dataset_comparison G.8275.x
          G.8275.defaultDS.localPriority 128
          #
          # Port Data Set
          #
          logAnnounceInterval -3
          logSyncInterval -4
          logMinDelayReqInterval -4
          logMinPdelayReqInterval -4
          announceReceiptTimeout 3
          syncReceiptTimeout 0
          delayAsymmetry 0
          fault_reset_interval -4
          neighborPropDelayThresh 20000000
          masterOnly 0
          G.8275.portDS.localPriority 128
          #
```

```
# Run time options
#
assume_two_step 0
logging_level 6
path_trace_enabled 0
follow_up_info 0
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 7
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
max_frequency 900000000
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type OC
network_transport L2
delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
```

```
        egressLatency 0
        ingressLatency 0
        boundary_clock_jbod 0
        #
        # Clock description
        #
        productDescription ;;
        revisionData ;;
        manufacturerIdentity 00:00:00
        userDescription ;
        timeSource 0xA0
    ptpClockThreshold: 5
      holdOverTimeout: 30 # seconds
      maxOffsetThreshold: 100  # nano seconds
      minOffsetThreshold: -100
```

1. Can be one of **PtpConfigMaster.yaml**, **PtpConfigSlave.yaml**, or **PtpConfigSlaveCvl.yaml** depending on your requirements. **PtpConfigSlaveCvl.yaml** configures **linuxptp** services for an Intel E810 Columbiaville NIC. For configurations based on **acm-group-du-sno-ranGen.yaml** or **acm-group-du-3node-ranGen.yaml**, use **PtpConfigSlave.yaml**.
2. Device specific interface name.
3. You must append the **--summary_interval -4** value to **ptp4lOpts** in **.spec.sourceFiles.spec.profile** to enable PTP fast events.
4. Required **phc2sysOpts** values. **-m** prints messages to **stdout**. The **linuxptp-daemon DaemonSet** parses the logs and generates Prometheus metrics.
5. Optional. If the **ptpClockThreshold** stanza is not present, default values are used for the **ptpClockThreshold** fields. The stanza shows default **ptpClockThreshold** values. The **ptpClockThreshold** values configure how long after the PTP master clock is disconnected before PTP events are triggered. **holdOverTimeout** is the time value in seconds before the PTP clock event state changes to **FREERUN** when the PTP master clock is disconnected. The **maxOffsetThreshold** and **minOffsetThreshold** settings configure offset values in nanoseconds that compare against the values for **CLOCK_REALTIME** (**phc2sys**) or master offset (**ptp4l**). When the **ptp4l** or **phc2sys** offset value is outside this range, the PTP clock state is set to **FREERUN**. When the offset value is within this range, the PTP clock state is set to **LOCKED**.

2. Merge any other required changes and files with your custom site repository.
3. Push the changes to your site configuration repository to deploy PTP fast events to new sites using GitOps ZTP.

Additional resources

- Using PolicyGenerator CRs to override source CRs content

9.2.8.2. Configuring PTP events that use AMQP transport

You can configure PTP events that use AMQP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, Red Hat AMQ Interconnect support status.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. Add the following YAML into **policies.manifests** in the **acm-common-ranGen.yaml** file to configure the AMQP Operator:

```
#AMQ Interconnect Operator for fast events
- path: source-crs/AmqSubscriptionNS.yaml
- path: source-crs/AmqSubscriptionOperGroup.yaml
- path: source-crs/AmqSubscription.yaml
```

2. Apply the following **PolicyGenerator** changes to **acm-group-du-3node-ranGen.yaml**, **acm-group-du-sno-ranGen.yaml**, or **acm-group-du-standard-ranGen.yaml** files according to your requirements:

   a. In **policies.manifests**, add the **PtpOperatorConfig** CR file that configures the AMQ transport host to the **config-policy**:

```
- path: source-crs/PtpOperatorConfigForEvent.yaml
  patches:
  - metadata:
      name: default
      namespace: openshift-ptp
      annotations:
        ran.openshift.io/ztp-deploy-wave: "10"
    spec:
      daemonNodeSelector:
        node-role.kubernetes.io/$mcp: ""
      ptpEventConfig:
        enableEventPublisher: true
        transportHost: "amqp://amq-router.amq-router.svc.cluster.local"
```

   b. Configure the **linuxptp** and **phc2sys** for the PTP clock type and interface. For example, add the following YAML into **policies.manifests**:

```
- path: source-crs/PtpConfigSlave.yaml (1)
  patches:
  - metadata:
      name: "du-ptp-slave"
    spec:
```

```
recommend:
- match:
  - nodeLabel: node-role.kubernetes.io/master
  priority: 4
  profile: slave
profile:
- name: "slave"
  # This interface must match the hardware in this group
  interface: "ens5f0" 2
  ptp4lOpts: "-2 -s --summary_interval -4" 3
  phc2sysOpts: "-a -r -n 24" 4
  ptpSchedulingPolicy: SCHED_FIFO
  ptpSchedulingPriority: 10
  ptpSettings:
    logReduce: "true"
  ptp4lConf: |
    [global]
    #
    # Default Data Set
    #
    twoStepFlag 1
    slaveOnly 1
    priority1 128
    priority2 128
    domainNumber 24
    #utc_offset 37
    clockClass 255
    clockAccuracy 0xFE
    offsetScaledLogVariance 0xFFFF
    free_running 0
    freq_est_interval 1
    dscp_event 0
    dscp_general 0
    dataset_comparison G.8275.x
    G.8275.defaultDS.localPriority 128
    #
    # Port Data Set
    #
    logAnnounceInterval -3
    logSyncInterval -4
    logMinDelayReqInterval -4
    logMinPdelayReqInterval -4
    announceReceiptTimeout 3
    syncReceiptTimeout 0
    delayAsymmetry 0
    fault_reset_interval -4
    neighborPropDelayThresh 20000000
    masterOnly 0
    G.8275.portDS.localPriority 128
    #
    # Run time options
    #
    assume_two_step 0
    logging_level 6
    path_trace_enabled 0
    follow_up_info 0
```

```
hybrid_e2e 0
inhibit_multicast_service 0
net_sync_monitor 0
tc_spanning_tree 0
tx_timestamp_timeout 50
unicast_listen 0
unicast_master_table 0
unicast_req_duration 3600
use_syslog 1
verbose 0
summary_interval 0
kernel_leap 1
check_fup_sync 0
clock_class_threshold 7
#
# Servo Options
#
pi_proportional_const 0.0
pi_integral_const 0.0
pi_proportional_scale 0.0
pi_proportional_exponent -0.3
pi_proportional_norm_max 0.7
pi_integral_scale 0.0
pi_integral_exponent 0.4
pi_integral_norm_max 0.3
step_threshold 2.0
first_step_threshold 0.00002
max_frequency 900000000
clock_servo pi
sanity_freq_limit 200000000
ntpshm_segment 0
#
# Transport options
#
transportSpecific 0x0
ptp_dst_mac 01:1B:19:00:00:00
p2p_dst_mac 01:80:C2:00:00:0E
udp_ttl 1
udp6_scope 0x0E
uds_address /var/run/ptp4l
#
# Default interface options
#
clock_type OC
network_transport L2
delay_mechanism E2E
time_stamping hardware
tsproc_mode filter
delay_filter moving_median
delay_filter_length 10
egressLatency 0
ingressLatency 0
boundary_clock_jbod 0
#
# Clock description
#
```

```
          productDescription ;;
          revisionData ;;
          manufacturerIdentity 00:00:00
          userDescription ;
          timeSource 0xA0
    ptpClockThreshold: 5
      holdOverTimeout: 30 # seconds
      maxOffsetThreshold: 100  # nano seconds
      minOffsetThreshold: -100
```

1. Can be one of **PtpConfigMaster.yaml**, **PtpConfigSlave.yaml**, or **PtpConfigSlaveCvl.yaml** depending on your requirements. **PtpConfigSlaveCvl.yaml** configures **linuxptp** services for an Intel E810 Columbiaville NIC. For configurations based on **acm-group-du-sno-ranGen.yaml** or **acm-group-du-3node-ranGen.yaml**, use **PtpConfigSlave.yaml**.

2. Device specific interface name.

3. You must append the **--summary_interval -4** value to **ptp4lOpts** in **.spec.sourceFiles.spec.profile** to enable PTP fast events.

4. Required **phc2sysOpts** values. **-m** prints messages to **stdout**. The **linuxptp-daemon DaemonSet** parses the logs and generates Prometheus metrics.

5. Optional. If the **ptpClockThreshold** stanza is not present, default values are used for the **ptpClockThreshold** fields. The stanza shows default **ptpClockThreshold** values. The **ptpClockThreshold** values configure how long after the PTP master clock is disconnected before PTP events are triggered. **holdOverTimeout** is the time value in seconds before the PTP clock event state changes to **FREERUN** when the PTP master clock is disconnected. The **maxOffsetThreshold** and **minOffsetThreshold** settings configure offset values in nanoseconds that compare against the values for **CLOCK_REALTIME** (**phc2sys**) or master offset (**ptp4l**). When the **ptp4l** or **phc2sys** offset value is outside this range, the PTP clock state is set to **FREERUN**. When the offset value is within this range, the PTP clock state is set to **LOCKED**.

3. Apply the following **PolicyGenerator** changes to your specific site YAML files, for example, **acm-example-sno-site.yaml**:

    a. In **policies.manifests**, add the **Interconnect** CR file that configures the AMQ router to the **config-policy**:

    ```
    - path: source-crs/AmqInstance.yaml
    ```

4. Merge any other required changes and files with your custom site repository.

5. Push the changes to your site configuration repository to deploy PTP fast events to new sites using GitOps ZTP.

Additional resources

- Installing the AMQ messaging bus
- OpenShift image registry overview

9.2.9. Configuring bare-metal events with PolicyGenerator CRs

You can use the GitOps ZTP pipeline to configure bare-metal events that use HTTP or AMQP transport.

> **NOTE**
>
> HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, Red Hat AMQ Interconnect support status.

9.2.9.1. Configuring bare-metal events that use HTTP transport

You can configure bare-metal events that use HTTP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. Configure the Bare Metal Event Relay Operator by adding the following YAML to **policies.manifests** in the **acm-common-ranGen.yaml** file:

```
# Bare Metal Event Relay Operator
- path: source-crs/BareMetalEventRelaySubscriptionNS.yaml
- path: source-crs/BareMetalEventRelaySubscriptionOperGroup.yaml
- path: source-crs/BareMetalEventRelaySubscription.yaml
```

2. Add the **HardwareEvent** CR to **policies.manifests** in your specific group configuration file, for example, in the **acm-group-du-sno-ranGen.yaml** file:

```
- path: source-crs/HardwareEvent.yaml (1)
  patches:
    - spec:
        logLevel: debug
        nodeSelector: {}
        transportHost: http://hw-event-publisher-service.openshift-bare-metal-
events.svc.cluster.local:9043
```

(1) Each baseboard management controller (BMC) requires a single **HardwareEvent** CR only.

> **NOTE**
>
> In OpenShift Container Platform 4.13 or later, you do not need to set the **transportHost** field in the **HardwareEvent** custom resource (CR) when you use HTTP transport with bare-metal events.

3. Merge any other required changes and files with your custom site repository.

4. Push the changes to your site configuration repository to deploy bare-metal events to new sites with GitOps ZTP.

5. Create the Redfish Secret by running the following command:

```
$ oc -n openshift-bare-metal-events create secret generic redfish-basic-auth \
--from-literal=username=<bmc_username> --from-literal=password=<bmc_password> \
--from-literal=hostaddr="<bmc_host_ip_addr>"
```

Additional resources

- Installing the Bare Metal Event Relay using the CLI
- Creating the bare-metal event and Secret CRs

9.2.9.2. Configuring bare-metal events that use AMQP transport

You can configure bare-metal events that use AMQP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

> **NOTE**
>
> HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, Red Hat AMQ Interconnect support status.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. To configure the AMQ Interconnect Operator and the Bare Metal Event Relay Operator, add the following YAML to **policies.manifests** in the **acm-common-ranGen.yaml** file:

```
# AMQ Interconnect Operator for fast events
- path: source-crs/AmqSubscriptionNS.yaml
- path: source-crs/AmqSubscriptionOperGroup.yaml
- path: source-crs/AmqSubscription.yaml
# Bare Metal Event Relay Operator
```

```
- path: source-crs/BareMetalEventRelaySubscriptionNS.yaml
- path: source-crs/BareMetalEventRelaySubscriptionOperGroup.yaml
- path: source-crs/BareMetalEventRelaySubscription.yaml
```

2. Add the **Interconnect** CR to **policies.manifests** in the site configuration file, for example, the **acm-example-sno-site.yaml** file:

```
- path: source-crs/AmqInstance.yaml
```

3. Add the **HardwareEvent** CR to **policies.manifests** in your specific group configuration file, for example, in the **acm-group-du-sno-ranGen.yaml** file:

```
- path: HardwareEvent.yaml
  patches:
    nodeSelector: {}
    transportHost: "amqp://<amq_interconnect_name>.
<amq_interconnect_namespace>.svc.cluster.local" 1
    logLevel: "info"
```

1 The **transportHost** URL is composed of the existing AMQ Interconnect CR **name** and **namespace**. For example, in **transportHost: "amqp://amq-router.amq-router.svc.cluster.local"**, the AMQ Interconnect **name** and **namespace** are both set to **amq-router**.

NOTE

Each baseboard management controller (BMC) requires a single **HardwareEvent** resource only.

4. Commit the **PolicyGenerator** change in Git, and then push the changes to your site configuration repository to deploy bare-metal events monitoring to new sites using GitOps ZTP.

5. Create the Redfish Secret by running the following command:

```
$ oc -n openshift-bare-metal-events create secret generic redfish-basic-auth \
--from-literal=username=<bmc_username> --from-literal=password=<bmc_password> \
--from-literal=hostaddr="<bmc_host_ip_addr>"
```

9.2.10. Configuring the Image Registry Operator for local caching of images

OpenShift Container Platform manages image caching using a local registry. In edge computing use cases, clusters are often subject to bandwidth restrictions when communicating with centralized image registries, which might result in long image download times.

Long download times are unavoidable during initial deployment. Over time, there is a risk that CRI-O will erase the **/var/lib/containers/storage** directory in the case of an unexpected shutdown. To address long image download times, you can create a local image registry on remote managed clusters using GitOps Zero Touch Provisioning (ZTP). This is useful in Edge computing scenarios where clusters are deployed at the far edge of the network.

Before you can set up the local image registry with GitOps ZTP, you need to configure disk partitioning in the **SiteConfig** CR that you use to install the remote managed cluster. After installation, you configure the local image registry using a **PolicyGenerator** CR. Then, the GitOps ZTP pipeline creates Persistent Volume (PV) and Persistent Volume Claim (PVC) CRs and patches the **imageregistry** configuration.

NOTE

The local image registry can only be used for user application images and cannot be used for the OpenShift Container Platform or Operator Lifecycle Manager operator images.

Additional resources

- OpenShift Container Platform registry overview

9.2.10.1. Configuring disk partitioning with SiteConfig

Configure disk partitioning for a managed cluster using a **SiteConfig** CR and GitOps Zero Touch Provisioning (ZTP). The disk partition details in the **SiteConfig** CR must match the underlying disk.

IMPORTANT

You must complete this procedure at installation time.

Prerequisites

- Install Butane.

Procedure

1. Create the **storage.bu** file.

```
variant: fcos
version: 1.3.0
storage:
  disks:
  - device: /dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0 1
    wipe_table: false
    partitions:
    - label: var-lib-containers
      start_mib: <start_of_partition> 2
      size_mib: <partition_size> 3
  filesystems:
    - path: /var/lib/containers
      device: /dev/disk/by-partlabel/var-lib-containers
      format: xfs
      wipe_filesystem: true
      with_mount_unit: true
      mount_options:
        - defaults
        - prjquota
```

1 Specify the root disk.

2 Specify the start of the partition in MiB. If the value is too small, the installation fails.

3 Specify the size of the partition. If the value is too small, the deployments fails.

2. Convert the **storage.bu** to an Ignition file by running the following command:

```
$ butane storage.bu
```

Example output

```
{"ignition":{"version":"3.2.0"},"storage":{"disks":[{"device":"/dev/disk/by-path/pci-0000:01:00.0-
scsi-0:2:0:0","partitions":[{"label":"var-lib-
containers","sizeMiB":0,"startMiB":250000}],"wipeTable":false}],"filesystems":
[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":
["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}]},"systemd":{"units":
[{"contents":"# # Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-
fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}
```

3. Use a tool such as JSON Pretty Print to convert the output into JSON format.

4. Copy the output into the **.spec.clusters.nodes.ignitionConfigOverride** field in the **SiteConfig** CR.

Example

```
[...]
spec:
  clusters:
    - nodes:
        - ignitionConfigOverride: |
          {
            "ignition": {
              "version": "3.2.0"
            },
            "storage": {
              "disks": [
                {
                  "device": "/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0",
                  "partitions": [
                    {
                      "label": "var-lib-containers",
                      "sizeMiB": 0,
                      "startMiB": 250000
                    }
                  ],
                  "wipeTable": false
                }
              ],
              "filesystems": [
                {
                  "device": "/dev/disk/by-partlabel/var-lib-containers",
                  "format": "xfs",
                  "mountOptions": [
                    "defaults",
                    "prjquota"
                  ],
                  "path": "/var/lib/containers",
                  "wipeFilesystem": true
                }
              ]
            },
            "systemd": {
              "units": [
                {
                  "contents": "# # Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-fs.target",
                  "enabled": true,
                  "name": "var-lib-containers.mount"
                }
              ]
            }
          }
[...]
```

NOTE

If the **.spec.clusters.nodes.ignitionConfigOverride** field does not exist, create it.

Verification

1. During or after installation, verify on the hub cluster that the **BareMetalHost** object shows the annotation by running the following command:

```
$ oc get bmh -n my-sno-ns my-sno -ojson | jq '.metadata.annotations["bmac.agent-
install.openshift.io/ignition-config-overrides"]
```

Example output

```
"{\"ignition\":{\"version\":\"3.2.0\"},\"storage\":{\"disks\":[{\"device\":\"/dev/disk/by-id/wwn-
0x6b07b250ebb9d0002a33509f24af1f62\",\"partitions\":[{\"label\":\"var-lib-
containers\",\"sizeMiB\":0,\"startMiB\":250000}],\"wipeTable\":false}],\"filesystems\":
[{\"device\":\"/dev/disk/by-partlabel/var-lib-containers\",\"format\":\"xfs\",\"mountOptions\":
[\"defaults\",\"prjquota\"],\"path\":\"/var/lib/containers\",\"wipeFilesystem\":true}]},\"systemd\":
{\"units\":[{\"contents\":\"# Generated by Butane\\n[Unit]\\nRequires=systemd-fsck@dev-disk-
by\\\\x2dpartlabel-var\\\\x2dlib\\\\x2dcontainers.service\\nAfter=systemd-fsck@dev-disk-
by\\\\x2dpartlabel-
var\\\\x2dlib\\\\x2dcontainers.service\\n\\n[Mount]\\nWhere=/var/lib/containers\\nWhat=/dev/disk/
by-partlabel/var-lib-
containers\\nType=xfs\\nOptions=defaults,prjquota\\n\\n[Install]\\nRequiredBy=local-
fs.target\",\"enabled\":true,\"name\":\"var-lib-containers.mount\"}]}}"
```

2. After installation, check the single-node OpenShift disk status.

   a. Enter into a debug session on the single-node OpenShift node by running the following command. This step instantiates a debug pod called **<node_name>-debug**:

   ```
   $ oc debug node/my-sno-node
   ```

   b. Set **/host** as the root directory within the debug shell by running the following command. The debug pod mounts the host's root file system in **/host** within the pod. By changing the root directory to **/host**, you can run binaries contained in the host's executable paths:

   ```
   # chroot /host
   ```

   c. List information about all available block devices by running the following command:

   ```
   # lsblk
   ```

   Example output

   ```
   NAME   MAJ:MIN RM   SIZE RO TYPE MOUNTPOINTS
   sda      8:0    0 446.6G  0 disk
    ├─sda1   8:1    0     1M  0 part
    ├─sda2   8:2    0   127M  0 part
    ├─sda3   8:3    0   384M  0 part /boot
    ├─sda4   8:4    0 243.6G  0 part /var
    │                                /sysroot/ostree/deploy/rhcos/var
    │                                /usr
    │                                /etc
    │                                /
    │                                /sysroot
    └─sda5   8:5    0 202.5G  0 part /var/lib/containers
   ```

   d. Display information about the file system disk space usage by running the following command:

   ```
   # df -h
   ```

   Example output

   ```
   Filesystem      Size  Used Avail Use% Mounted on
   devtmpfs        4.0M     0  4.0M   0% /dev
   tmpfs           126G   84K  126G   1% /dev/shm
   tmpfs            51G   93M   51G   1% /run
   /dev/sda4       244G  5.2G  239G   3% /sysroot
   tmpfs           126G  4.0K  126G   1% /tmp
   /dev/sda5       203G  119G   85G  59% /var/lib/containers
   /dev/sda3       350M  110M  218M  34% /boot
   tmpfs            26G     0   26G   0% /run/user/1000
   ```

9.2.10.2. Configuring the image registry using PolicyGenerator CRs

Use **PolicyGenerator** (PGT) CRs to apply the CRs required to configure the image registry and patch the **imageregistry** configuration.

Prerequisites

- You have configured a disk partition in the managed cluster.
- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data for use with GitOps Zero Touch Provisioning (ZTP).

Procedure

1. Configure the storage class, persistent volume claim, persistent volume, and image registry configuration in the appropriate **PolicyGenerator** CR. For example, to configure an individual site, add the following YAML to the file **acm-example-sno-site.yaml**:

```
sourceFiles:
 # storage class
 - fileName: StorageClass.yaml
   policyName: "sc-for-image-registry"
   metadata:
     name: image-registry-sc
     annotations:
       ran.openshift.io/ztp-deploy-wave: "100" (1)
 # persistent volume claim
 - fileName: StoragePVC.yaml
   policyName: "pvc-for-image-registry"
   metadata:
     name: image-registry-pvc
     namespace: openshift-image-registry
     annotations:
       ran.openshift.io/ztp-deploy-wave: "100"
   spec:
     accessModes:
       - ReadWriteMany
     resources:
       requests:
         storage: 100Gi
     storageClassName: image-registry-sc
     volumeMode: Filesystem
 # persistent volume
 - fileName: ImageRegistryPV.yaml (2)
   policyName: "pv-for-image-registry"
   metadata:
     annotations:
       ran.openshift.io/ztp-deploy-wave: "100"
 - fileName: ImageRegistryConfig.yaml
   policyName: "config-for-image-registry"
   complianceType: musthave
   metadata:
     annotations:
       ran.openshift.io/ztp-deploy-wave: "100"
   spec:
    storage:
      pvc:
        claim: "image-registry-pvc"
```

1. Set the appropriate value for **ztp-deploy-wave** depending on whether you are configuring image registries at the site, common, or group level. **ztp-deploy-wave: "100"** is suitable for development or testing because it allows you to group the referenced source files together.

2. In **ImageRegistryPV.yaml**, ensure that the **spec.local.path** field is set to **/var/imageregistry** to match the value set for the **mount_point** field in the **SiteConfig** CR.

IMPORTANT

Do not set **complianceType: mustonlyhave** for the **- fileName: ImageRegistryConfig.yaml** configuration. This can cause the registry pod deployment to fail.

2. Commit the **PolicyGenerator** change in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.

Verification

Use the following steps to troubleshoot errors with the local image registry on the managed clusters:

- Verify successful login to the registry while logged in to the managed cluster. Run the following commands:

  a. Export the managed cluster name:

  ```
  $ cluster=<managed_cluster_name>
  ```

  b. Get the managed cluster **kubeconfig** details:

  ```
  $ oc get secret -n $cluster $cluster-admin-password -o jsonpath='{.data.password}' |
  base64 -d > kubeadmin-password-$cluster
  ```

  c. Download and export the cluster **kubeconfig**:

  ```
  $ oc get secret -n $cluster $cluster-admin-kubeconfig -o jsonpath='{.data.kubeconfig}' |
  base64 -d > kubeconfig-$cluster && export KUBECONFIG=./kubeconfig-$cluster
  ```

  d. Verify access to the image registry from the managed cluster. See "Accessing the registry".

- Check that the **Config** CRD in the **imageregistry.operator.openshift.io** group instance is not reporting errors. Run the following command while logged in to the managed cluster:

  ```
  $ oc get image.config.openshift.io cluster -o yaml
  ```

  Example output

  ```
  apiVersion: config.openshift.io/v1
  kind: Image
  ```

```
metadata:
  annotations:
    include.release.openshift.io/ibm-cloud-managed: "true"
    include.release.openshift.io/self-managed-high-availability: "true"
    include.release.openshift.io/single-node-developer: "true"
    release.openshift.io/create-only: "true"
  creationTimestamp: "2021-10-08T19:02:39Z"
  generation: 5
  name: cluster
  resourceVersion: "688678648"
  uid: 0406521b-39c0-4cda-ba75-873697da75a4
spec:
  additionalTrustedCA:
    name: acm-ice
```

- Check that the **PersistentVolumeClaim** on the managed cluster is populated with data. Run the following command while logged in to the managed cluster:

```
$ oc get pv image-registry-sc
```

- Check that the **registry*** pod is running and is located under the **openshift-image-registry** namespace.

```
$ oc get pods -n openshift-image-registry | grep registry*
```

Example output

```
cluster-image-registry-operator-68f5c9c589-42cfg   1/1     Running     0          8d
image-registry-5f8987879-6nx6h                     1/1     Running     0          8d
```

- Check that the disk partition on the managed cluster is correct:

  a. Open a debug shell to the managed cluster:

  ```
  $ oc debug node/sno-1.example.com
  ```

  b. Run **lsblk** to check the host disk partitions:

  ```
  sh-4.4# lsblk
  NAME   MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
  sda      8:0    0 446.6G  0 disk
    |-sda1   8:1    0     1M  0 part
    |-sda2   8:2    0   127M  0 part
    |-sda3   8:3    0   384M  0 part /boot
    |-sda4   8:4    0 336.3G  0 part /sysroot
    `-sda5   8:5    0 100.1G  0 part /var/imageregistry 1
  sdb      8:16   0 446.6G  0 disk
  sr0     11:0    1   104M  0 rom
  ```

  1 **/var/imageregistry** indicates that the disk is correctly partitioned.

Additional resources

- Accessing the registry

9.3. UPDATING MANAGED CLUSTERS IN A DISCONNECTED ENVIRONMENT WITH POLICYGENERATOR RESOURCES AND TALM

You can use the Topology Aware Lifecycle Manager (TALM) to manage the software lifecycle of managed clusters that you have deployed using GitOps Zero Touch Provisioning (ZTP) and Topology Aware Lifecycle Manager (TALM). TALM uses Red Hat Advanced Cluster Management (RHACM) PolicyGenerator policies to manage and control changes applied to target clusters.

IMPORTANT

Using PolicyGenerator resources with GitOps ZTP is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

Additional resources

- For more information about the Topology Aware Lifecycle Manager, see About the Topology Aware Lifecycle Manager.

9.3.1. Setting up the disconnected environment

TALM can perform both platform and Operator updates.

You must mirror both the platform image and Operator images that you want to update to in your mirror registry before you can use TALM to update your disconnected clusters. Complete the following steps to mirror the images:

- For platform updates, you must perform the following steps:

  1. Mirror the desired OpenShift Container Platform image repository. Ensure that the desired platform image is mirrored by following the "Mirroring the OpenShift Container Platform image repository" procedure linked in the Additional Resources. Save the contents of the **imageContentSources** section in the **imageContentSources.yaml** file:

     Example output

```
imageContentSources:
 - mirrors:
   - mirror-ocp-registry.ibmcloud.io.cpak:5000/openshift-release-dev/openshift4
   source: quay.io/openshift-release-dev/ocp-release
 - mirrors:
   - mirror-ocp-registry.ibmcloud.io.cpak:5000/openshift-release-dev/openshift4
   source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

2. Save the image signature of the desired platform image that was mirrored. You must add the image signature to the **PolicyGenerator** CR for platform updates. To get the image signature, perform the following steps:

   a. Specify the desired OpenShift Container Platform tag by running the following command:

   ```
   $ OCP_RELEASE_NUMBER=<release_version>
   ```

   b. Specify the architecture of the cluster by running the following command:

   ```
   $ ARCHITECTURE=<cluster_architecture> 1
   ```

   1 Specify the architecture of the cluster, such as **x86_64**, **aarch64**, **s390x**, or **ppc64le**.

   c. Get the release image digest from Quay by running the following command

   ```
   $ DIGEST="$(oc adm release info quay.io/openshift-release-dev/ocp-
   release:${OCP_RELEASE_NUMBER}-${ARCHITECTURE} | sed -n 's/Pull From:
   .*@//p')"
   ```

   d. Set the digest algorithm by running the following command:

   ```
   $ DIGEST_ALGO="${DIGEST%%:*}"
   ```

   e. Set the digest signature by running the following command:

   ```
   $ DIGEST_ENCODED="${DIGEST#*:}"
   ```

   f. Get the image signature from the mirror.openshift.com website by running the following command:

   ```
   $ SIGNATURE_BASE64=$(curl -s "https://mirror.openshift.com/pub/openshift-
   v4/signatures/openshift/release/${DIGEST_ALGO}=${DIGEST_ENCODED}/signature
   -1" | base64 -w0 && echo)
   ```

   g. Save the image signature to the **checksum-<OCP_RELEASE_NUMBER>.yaml** file by running the following commands:

   ```
   $ cat >checksum-${OCP_RELEASE_NUMBER}.yaml <<EOF
   ${DIGEST_ALGO}-${DIGEST_ENCODED}: ${SIGNATURE_BASE64}
   EOF
   ```

3. Prepare the update graph. You have two options to prepare the update graph:

   a. Use the OpenShift Update Service.
   For more information about how to set up the graph on the hub cluster, see Deploy the operator for OpenShift Update Service and Build the graph data init container .

   b. Make a local copy of the upstream graph. Host the update graph on an **http** or **https** server in the disconnected environment that has access to the managed cluster. To download the update graph, use the following command:

```
$ curl -s https://api.openshift.com/api/upgrades_info/v1/graph?channel=stable-4.16 -
o ~/upgrade-graph_stable-4.16
```

- For Operator updates, you must perform the following task:
  - Mirror the Operator catalogs. Ensure that the desired operator images are mirrored by following the procedure in the "Mirroring Operator catalogs for use with disconnected clusters" section.

Additional resources

- For more information about how to update GitOps Zero Touch Provisioning (ZTP), see Upgrading GitOps ZTP .
- For more information about how to mirror an OpenShift Container Platform image repository, see Mirroring the OpenShift Container Platform image repository .
- For more information about how to mirror Operator catalogs for disconnected clusters, see Mirroring Operator catalogs for use with disconnected clusters .
- For more information about how to prepare the disconnected environment and mirroring the desired image repository, see Preparing the disconnected environment.
- For more information about update channels and releases, see Understanding update channels and releases.

9.3.2. Performing a platform update with PolicyGenerator CRs

You can perform a platform update with the TALM.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Mirror the desired image repository.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Create a **PolicyGenerator** CR for the platform update:
   a. Save the following **PolicyGenerator** CR in the **du-upgrade.yaml** file:

      Example of PolicyGenerator for platform update

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
    name: du-upgrade
placementBindingDefaults:
    name: du-upgrade-placement-binding
policyDefaults:
    namespace: ztp-group-du-sno
    placement:
        labelSelector:
            matchExpressions:
                - key: group-du-sno
                  operator: Exists
    remediationAction: inform
    severity: low
    namespaceSelector:
        exclude:
            - kube-*
        include:
            - '*'
    evaluationInterval:
        compliant: 10m
        noncompliant: 10s
policies:
    - name: du-upgrade-platform-upgrade
      policyAnnotations:
        ran.openshift.io/ztp-deploy-wave: "100"
      manifests:
        - path: source-crs/ClusterVersion.yaml 1
          patches:
            - metadata:
                name: version
              spec:
                channel: stable-4.16
                desiredUpdate:
                    version: 4.16.4
                upstream: http://upgrade.example.com/images/upgrade-graph_stable-4.16
              status:
                history:
                    - state: Completed
                      version: 4.16.4
    - name: du-upgrade-platform-upgrade-prep
      policyAnnotations:
        ran.openshift.io/ztp-deploy-wave: "1"
      manifests:
        - path: source-crs/ImageSignature.yaml 2
        - path: source-crs/DisconnectedICSP.yaml
          patches:
            - metadata:
                name: disconnected-internal-icsp-for-ocp
              spec:
                repositoryDigestMirrors: 3
                    - mirrors:
                        - quay-intern.example.com/ocp4/openshift-release-dev
                      source: quay.io/openshift-release-dev/ocp-release
                    - mirrors:
                        - quay-intern.example.com/ocp4/openshift-release-dev
                      source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
```

1. Shows the **ClusterVersion** CR to trigger the update. The **channel**, **upstream**, and **desiredVersion** fields are all required for image pre-caching.

2. **ImageSignature.yaml** contains the image signature of the required release image. The image signature is used to verify the image before applying the platform update.

3. Shows the mirror repository that contains the required OpenShift Container Platform image. Get the mirrors from the **imageContentSources.yaml** file that you saved when following the procedures in the "Setting up the environment" section.

The **PolicyGenerator** CR generates two policies:

- The **du-upgrade-platform-upgrade-prep** policy does the preparation work for the platform update. It creates the **ConfigMap** CR for the desired release image signature, creates the image content source of the mirrored release image repository, and updates the cluster version with the desired update channel and the update graph reachable by the managed cluster in the disconnected environment.

- The **du-upgrade-platform-upgrade** policy is used to perform platform upgrade.

b. Add the **du-upgrade.yaml** file contents to the **kustomization.yaml** file located in the GitOps ZTP Git repository for the **PolicyGenerator** CRs and push the changes to the Git repository.
ArgoCD pulls the changes from the Git repository and generates the policies on the hub cluster.

c. Check the created policies by running the following command:

```
$ oc get policies -A | grep platform-upgrade
```

2. Create the **ClusterGroupUpdate** CR for the platform update with the **spec.enable** field set to **false**.

a. Save the content of the platform update **ClusterGroupUpdate** CR with the **du-upgrade-platform-upgrade-prep** and the **du-upgrade-platform-upgrade** policies and the target clusters to the **cgu-platform-upgrade.yml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-platform-upgrade
  namespace: default
spec:
  managedPolicies:
  - du-upgrade-platform-upgrade-prep
  - du-upgrade-platform-upgrade
  preCaching: false
  clusters:
  - spoke1
  remediationStrategy:
    maxConcurrency: 1
  enable: false
```

b. Apply the **ClusterGroupUpdate** CR to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-upgrade.yml
```

3. Optional: Pre-cache the images for the platform update.

   a. Enable pre-caching in the **ClusterGroupUpdate** CR by running the following command:

   ```
   $ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-platform-
   upgrade \
   --patch '{"spec":{"preCaching": true}}' --type=merge
   ```

   b. Monitor the update process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the hub cluster:

   ```
   $ oc get cgu cgu-platform-upgrade -o jsonpath='{.status.precaching.status}'
   ```

4. Start the platform update:

   a. Enable the **cgu-platform-upgrade** policy and disable pre-caching by running the following command:

   ```
   $ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-platform-
   upgrade \
   --patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
   ```

   b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

   ```
   $ oc get policies --all-namespaces
   ```

Additional resources

- For more information about mirroring the images in a disconnected environment, see Preparing the disconnected environment.

9.3.3. Performing an Operator update with PolicyGenerator CRs

You can perform an Operator update with the TALM.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Mirror the desired index image, bundle images, and all Operator images referenced in the bundle images.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Update the **PolicyGenerator** CR for the Operator update.

   a. Update the **du-upgrade PolicyGenerator** CR with the following additional contents in the **du-upgrade.yaml** file:

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: du-upgrade
placementBindingDefaults:
  name: du-upgrade-placement-binding
policyDefaults:
  namespace: ztp-group-du-sno
  placement:
    labelSelector:
      matchExpressions:
        - key: group-du-sno
          operator: Exists
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: du-upgrade-operator-catsrc-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "1"
    manifests:
      - path: source-crs/DefaultCatsrc.yaml
        patches:
          - metadata:
              name: redhat-operators
            spec:
              displayName: Red Hat Operators Catalog
              image: registry.example.com:5000/olm/redhat-operators:v4.16 1
              updateStrategy: 2
                registryPoll:
                  interval: 1h
            status:
              connectionState:
                lastObservedState: READY 3
```

1 Contains the required Operator images. If the index images are always pushed to the same image name and tag, this change is not needed.

2 Sets how frequently the Operator Lifecycle Manager (OLM) polls the index image for new Operator versions with the **registryPoll.interval** field. This change is not needed if a new index image tag is always pushed for y-stream and z-stream Operator updates. The **registryPoll.interval** field can be set to a shorter interval to expedite the

update, however shorter intervals increase computational load. To counteract this, you can restore **registryPoll.interval** to the default value once the update is complete.

3 Displays the observed state of the catalog connection. The **READY** value ensures that the **CatalogSource** policy is ready, indicating that the index pod is pulled and is running. This way, TALM upgrades the Operators based on up-to-date policy compliance states.

b. This update generates one policy, **du-upgrade-operator-catsrc-policy**, to update the **redhat-operators** catalog source with the new index images that contain the desired Operators images.

NOTE

If you want to use the image pre-caching for Operators and there are Operators from a different catalog source other than **redhat-operators**, you must perform the following tasks:

- Prepare a separate catalog source policy with the new index image or registry poll interval update for the different catalog source.
- Prepare a separate subscription policy for the desired Operators that are from the different catalog source.

For example, the desired SRIOV-FEC Operator is available in the **certified-operators** catalog source. To update the catalog source and the Operator subscription, add the following contents to generate two policies, **du-upgrade-fec-catsrc-policy** and **du-upgrade-subscriptions-fec-policy**:

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: du-upgrade
placementBindingDefaults:
  name: du-upgrade-placement-binding
policyDefaults:
  namespace: ztp-group-du-sno
  placement:
    labelSelector:
      matchExpressions:
        - key: group-du-sno
          operator: Exists
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: du-upgrade-fec-catsrc-policy
```

```
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "1"
    manifests:
      - path: source-crs/DefaultCatsrc.yaml
        patches:
          - metadata:
              name: certified-operators
            spec:
              displayName: Intel SRIOV-FEC Operator
              image: registry.example.com:5000/olm/far-edge-sriov-fec:v4.10
              updateStrategy:
                registryPoll:
                  interval: 10m
  - name: du-upgrade-subscriptions-fec-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "2"
    manifests:
      - path: source-crs/AcceleratorsSubscription.yaml
        patches:
          - spec:
              channel: stable
              source: certified-operators
```

c. Remove the specified subscriptions channels in the common **PolicyGenerator** CR, if they exist. The default subscriptions channels from the GitOps ZTP image are used for the update.

> **NOTE**
>
> The default channel for the Operators applied through GitOps ZTP 4.16 is **stable**, except for the **performance-addon-operator**. As of OpenShift Container Platform 4.11, the **performance-addon-operator** functionality was moved to the **node-tuning-operator**. For the 4.10 release, the default channel for PAO is **v4.10**. You can also specify the default channels in the common **PolicyGenerator** CR.

d. Push the **PolicyGenerator** CRs updates to the GitOps ZTP Git repository.
ArgoCD pulls the changes from the Git repository and generates the policies on the hub cluster.

e. Check the created policies by running the following command:

```
$ oc get policies -A | grep -E "catsrc-policy|subscription"
```

2. Apply the required catalog source updates before starting the Operator update.

a. Save the content of the **ClusterGroupUpgrade** CR named **operator-upgrade-prep** with the catalog source policies and the target managed clusters to the **cgu-operator-upgrade-prep.yml** file:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-operator-upgrade-prep
  namespace: default
```

```
spec:
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - du-upgrade-operator-catsrc-policy
  remediationStrategy:
    maxConcurrency: 1
```

b. Apply the policy to the hub cluster by running the following command:

```
$ oc apply -f cgu-operator-upgrade-prep.yml
```

c. Monitor the update process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies -A | grep -E "catsrc-policy"
```

3. Create the **ClusterGroupUpgrade** CR for the Operator update with the **spec.enable** field set to **false**.

a. Save the content of the Operator update **ClusterGroupUpgrade** CR with the **du-upgrade-operator-catsrc-policy** policy and the subscription policies created from the common **PolicyGenerator** and the target clusters to the **cgu-operator-upgrade.yml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-operator-upgrade
  namespace: default
spec:
  managedPolicies:
  - du-upgrade-operator-catsrc-policy 1
  - common-subscriptions-policy 2
  preCaching: false
  clusters:
  - spoke1
  remediationStrategy:
    maxConcurrency: 1
  enable: false
```

1 The policy is needed by the image pre-caching feature to retrieve the operator images from the catalog source.

2 The policy contains Operator subscriptions. If you have followed the structure and content of the reference **PolicyGenTemplates**, all Operator subscriptions are grouped into the **common-subscriptions-policy** policy.

NOTE

One **ClusterGroupUpgrade** CR can only pre-cache the images of the desired Operators defined in the subscription policy from one catalog source included in the **ClusterGroupUpgrade** CR. If the desired Operators are from different catalog sources, such as in the example of the SRIOV-FEC Operator, another **ClusterGroupUpgrade** CR must be created with **du-upgrade-fec-catsrc-policy** and **du-upgrade-subscriptions-fec-policy** policies for the SRIOV-FEC Operator images pre-caching and update.

b. Apply the **ClusterGroupUpgrade** CR to the hub cluster by running the following command:

```
$ oc apply -f cgu-operator-upgrade.yml
```

4. Optional: Pre-cache the images for the Operator update.

a. Before starting image pre-caching, verify the subscription policy is **NonCompliant** at this point by running the following command:

```
$ oc get policy common-subscriptions-policy -n <policy_namespace>
```

Example output

```
NAME                          REMEDIATION ACTION   COMPLIANCE STATE     AGE
common-subscriptions-policy   inform               NonCompliant         27d
```

b. Enable pre-caching in the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-operator-
upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

c. Monitor the process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the managed cluster:

```
$ oc get cgu cgu-operator-upgrade -o jsonpath='{.status.precaching.status}'
```

d. Check if the pre-caching is completed before starting the update by running the following command:

```
$ oc get cgu -n default cgu-operator-upgrade -ojsonpath='{.status.conditions}' | jq
```

Example output

```
[
  {
    "lastTransitionTime": "2022-03-08T20:49:08.000Z",
    "message": "The ClusterGroupUpgrade CR is not enabled",
    "reason": "UpgradeNotStarted",
    "status": "False",
    "type": "Ready"
  },
  {
        "lastTransitionTime": "2022-03-08T20:55:30.000Z",
        "message": "Precaching is completed",
        "reason": "PrecachingCompleted",
        "status": "True",
        "type": "PrecachingDone"
      }
    ]
```

5. Start the Operator update.

   a. Enable the **cgu-operator-upgrade ClusterGroupUpgrade** CR and disable pre-caching to start the Operator update by running the following command:

   ```
   $ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-operator-upgrade \
   --patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
   ```

   b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

   ```
   $ oc get policies --all-namespaces
   ```

Additional resources

- For more information about updating GitOps ZTP, see Upgrading GitOps ZTP .

9.3.4. Troubleshooting missed Operator updates with PolicyGenerator CRs

In some scenarios, Topology Aware Lifecycle Manager (TALM) might miss Operator updates due to an out-of-date policy compliance state.

After a catalog source update, it takes time for the Operator Lifecycle Manager (OLM) to update the subscription status. The status of the subscription policy might continue to show as compliant while TALM decides whether remediation is needed. As a result, the Operator specified in the subscription policy does not get upgraded.

To avoid this scenario, add another catalog source configuration to the **PolicyGenerator** and specify this configuration in the subscription for any Operators that require an update.

Procedure

1. Add a catalog source configuration in the **PolicyGenerator** resource:

```
manifests:
- path: source-crs/DefaultCatsrc.yaml
  patches:
    - metadata:
        name: redhat-operators
      spec:
        displayName: Red Hat Operators Catalog
        image: registry.example.com:5000/olm/redhat-operators:v{product-version}
        updateStrategy:
          registryPoll:
            interval: 1h
```

```
      status:
        connectionState:
          lastObservedState: READY
  - path: source-crs/DefaultCatsrc.yaml
    patches:
    - metadata:
        name: redhat-operators-v2 (1)
      spec:
        displayName: Red Hat Operators Catalog v2 (2)
        image: registry.example.com:5000/olredhat-operators:<version> (3)
        updateStrategy:
          registryPoll:
            interval: 1h
      status:
        connectionState:
          lastObservedState: READY
```

(1) Update the name for the new configuration.

(2) Update the display name for the new configuration.

(3) Update the index image URL. This **policies.manifests.patches.spec.image** field overrides any configuration in the **DefaultCatsrc.yaml** file.

2. Update the **Subscription** resource to point to the new configuration for Operators that require an update:

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: operator-subscription
  namespace: operator-namspace
# ...
spec:
  source: redhat-operators-v2 (1)
# ...
```

(1) Enter the name of the additional catalog source configuration that you defined in the **PolicyGenerator** resource.

9.3.5. Performing a platform and an Operator update together

You can perform a platform and an Operator update at the same time.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Log in as a user with **cluster-admin** privileges.

- Create RHACM policies in the hub cluster.

Procedure

1. Create the **PolicyGenerator** CR for the updates by following the steps described in the "Performing a platform update" and "Performing an Operator update" sections.

2. Apply the prep work for the platform and the Operator update.

    a. Save the content of the **ClusterGroupUpgrade** CR with the policies for platform update preparation work, catalog source updates, and target clusters to the **cgu-platform-operator-upgrade-prep.yml** file, for example:

    ```
    apiVersion: ran.openshift.io/v1alpha1
    kind: ClusterGroupUpgrade
    metadata:
      name: cgu-platform-operator-upgrade-prep
      namespace: default
    spec:
      managedPolicies:
      - du-upgrade-platform-upgrade-prep
      - du-upgrade-operator-catsrc-policy
      clusterSelector:
      - group-du-sno
      remediationStrategy:
        maxConcurrency: 10
      enable: true
    ```

    b. Apply the **cgu-platform-operator-upgrade-prep.yml** file to the hub cluster by running the following command:

    ```
    $ oc apply -f cgu-platform-operator-upgrade-prep.yml
    ```

    c. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

    ```
    $ oc get policies --all-namespaces
    ```

3. Create the **ClusterGroupUpdate** CR for the platform and the Operator update with the **spec.enable** field set to **false**.

    a. Save the contents of the platform and Operator update **ClusterGroupUpdate** CR with the policies and the target clusters to the **cgu-platform-operator-upgrade.yml** file, as shown in the following example:

    ```
    apiVersion: ran.openshift.io/v1alpha1
    kind: ClusterGroupUpgrade
    metadata:
      name: cgu-du-upgrade
      namespace: default
    spec:
      managedPolicies:
      - du-upgrade-platform-upgrade (1)
      - du-upgrade-operator-catsrc-policy (2)
      - common-subscriptions-policy (3)
    ```

```
preCaching: true
clusterSelector:
- group-du-sno
remediationStrategy:
  maxConcurrency: 1
enable: false
```

1. This is the platform update policy.
2. This is the policy containing the catalog source information for the Operators to be updated. It is needed for the pre-caching feature to determine which Operator images to download to the managed cluster.
3. This is the policy to update the Operators.

b. Apply the **cgu-platform-operator-upgrade.yml** file to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-operator-upgrade.yml
```

4. Optional: Pre-cache the images for the platform and the Operator update.

a. Enable pre-caching in the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-du-upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

b. Monitor the update process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the managed cluster:

```
$ oc get jobs,pods -n openshift-talm-pre-cache
```

c. Check if the pre-caching is completed before starting the update by running the following command:

```
$ oc get cgu cgu-du-upgrade -ojsonpath='{.status.conditions}'
```

5. Start the platform and Operator update.

a. Enable the **cgu-du-upgrade ClusterGroupUpgrade** CR to start the platform and the Operator update by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-du-upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

NOTE

The CRs for the platform and Operator updates can be created from the beginning by configuring the setting to **spec.enable: true**. In this case, the update starts immediately after pre-caching completes and there is no need to manually enable the CR.

Both pre-caching and the update create extra resources, such as policies, placement bindings, placement rules, managed cluster actions, and managed cluster view, to help complete the procedures. Setting the **afterCompletion.deleteObjects** field to **true** deletes all these resources after the updates complete.

9.3.6. Removing Performance Addon Operator subscriptions from deployed clusters with PolicyGenerator CRs

In earlier versions of OpenShift Container Platform, the Performance Addon Operator provided automatic, low latency performance tuning for applications. In OpenShift Container Platform 4.11 or later, these functions are part of the Node Tuning Operator.

Do not install the Performance Addon Operator on clusters running OpenShift Container Platform 4.11 or later. If you upgrade to OpenShift Container Platform 4.11 or later, the Node Tuning Operator automatically removes the Performance Addon Operator.

NOTE

You need to remove any policies that create Performance Addon Operator subscriptions to prevent a re-installation of the Operator.

The reference DU profile includes the Performance Addon Operator in the **PolicyGenerator** CR **acm-common-ranGen.yaml**. To remove the subscription from deployed managed clusters, you must update **acm-common-ranGen.yaml**.

NOTE

If you install Performance Addon Operator 4.10.3-5 or later on OpenShift Container Platform 4.11 or later, the Performance Addon Operator detects the cluster version and automatically hibernates to avoid interfering with the Node Tuning Operator functions. However, to ensure best performance, remove the Performance Addon Operator from your OpenShift Container Platform 4.11 clusters.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for ArgoCD.
- Update to OpenShift Container Platform 4.11 or later.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Change the **complianceType** to **mustnothave** for the Performance Addon Operator namespace, Operator group, and subscription in the **acm-common-ranGen.yaml** file.

```
- name: group-du-sno-pg-subscriptions-policy
  policyAnnotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  manifests:
    - path: source-crs/PaoSubscriptionNS.yaml
    - path: source-crs/PaoSubscriptionOperGroup.yaml
    - path: source-crs/PaoSubscription.yaml
```

2. Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The status of the **common-subscriptions-policy** policy changes to **Non-Compliant**.

3. Apply the change to your target clusters by using the Topology Aware Lifecycle Manager. For more information about rolling out configuration changes, see the "Additional resources" section.

4. Monitor the process. When the status of the **common-subscriptions-policy** policy for a target cluster is **Compliant**, the Performance Addon Operator has been removed from the cluster. Get the status of the **common-subscriptions-policy** by running the following command:

```
$ oc get policy -n ztp-common common-subscriptions-policy
```

5. Delete the Performance Addon Operator namespace, Operator group and subscription CRs from **policies.manifests** in the **acm-common-ranGen.yaml** file.

6. Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The policy remains compliant.

9.3.7. Pre-caching user-specified images with TALM on single-node OpenShift clusters

You can pre-cache application-specific workload images on single-node OpenShift clusters before upgrading your applications.

You can specify the configuration options for the pre-caching jobs using the following custom resources (CR):

- **PreCachingConfig** CR
- **ClusterGroupUpgrade** CR

NOTE

All fields in the **PreCachingConfig** CR are optional.

Example PreCachingConfig CR

```
apiVersion: ran.openshift.io/v1alpha1
kind: PreCachingConfig
metadata:
  name: exampleconfig
  namespace: exampleconfig-ns
spec:
  overrides: 1
```

```
    platformImage: quay.io/openshift-release-dev/ocp-
release@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1ef
    operatorsIndexes:
      - registry.example.com:5000/custom-redhat-operators:1.0.0
    operatorsPackagesAndChannels:
      - local-storage-operator: stable
      - ptp-operator: stable
      - sriov-network-operator: stable
  spaceRequired: 30 Gi (2)
  excludePrecachePatterns: (3)
    - aws
    - vsphere
  additionalImages: (4)
    -
quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925
ada29c559a47e2e1ef
    -
quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d3808fc925
ada29c559a47adfaef
    -
quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafdedga099
1234afdadfsa09
```

1. By default, TALM automatically populates the **platformImage**, **operatorsIndexes**, and the **operatorsPackagesAndChannels** fields from the policies of the managed clusters. You can specify values to override the default TALM-derived values for these fields.

2. Specifies the minimum required disk space on the cluster. If unspecified, TALM defines a default value for OpenShift Container Platform images. The disk space field must include an integer value and the storage unit. For example: **40 GiB**, **200 MB**, **1 TiB**.

3. Specifies the images to exclude from pre-caching based on image name matching.

4. Specifies the list of additional images to pre-cache.

Example ClusterGroupUpgrade CR with PreCachingConfig CR reference

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu
spec:
  preCaching: true (1)
  preCachingConfigRef:
    name: exampleconfig (2)
    namespace: exampleconfig-ns (3)
```

1. The **preCaching** field set to **true** enables the pre-caching job.

2. The **preCachingConfigRef.name** field specifies the **PreCachingConfig** CR that you want to use.

3. The **preCachingConfigRef.namespace** specifies the namespace of the **PreCachingConfig** CR that you want to use.

9.3.7.1. Creating the custom resources for pre-caching

You must create the **PreCachingConfig** CR before or concurrently with the **ClusterGroupUpgrade** CR.

1. Create the **PreCachingConfig** CR with the list of additional images you want to pre-cache.

```
apiVersion: ran.openshift.io/v1alpha1
kind: PreCachingConfig
metadata:
  name: exampleconfig
  namespace: default (1)
spec:
[...]
  spaceRequired: 30Gi (2)
  additionalImages:
    -
quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d38
08fc925ada29c559a47e2e1ef
    -
quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d38
08fc925ada29c559a47adfaef
    -
quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafd
edga0991234afdadfsa09
```

(1) The **namespace** must be accessible to the hub cluster.

(2) It is recommended to set the minimum disk space required field to ensure that there is sufficient storage space for the pre-cached images.

2. Create a **ClusterGroupUpgrade** CR with the **preCaching** field set to **true** and specify the **PreCachingConfig** CR created in the previous step:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu
  namespace: default
spec:
  clusters:
  - sno1
  - sno2
  preCaching: true
  preCachingConfigRef:
  - name: exampleconfig
    namespace: default
  managedPolicies:
    - du-upgrade-platform-upgrade
    - du-upgrade-operator-catsrc-policy
    - common-subscriptions-policy
  remediationStrategy:
    timeout: 240
```

WARNING

Once you install the images on the cluster, you cannot change or delete them.

3. When you want to start pre-caching the images, apply the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f cgu.yaml
```

TALM verifies the **ClusterGroupUpgrade** CR.

From this point, you can continue with the TALM pre-caching workflow.

NOTE

All sites are pre-cached concurrently.

Verification

1. Check the pre-caching status on the hub cluster where the **ClusterUpgradeGroup** CR is applied by running the following command:

```
$ oc get cgu <cgu_name> -n <cgu_namespace> -oyaml
```

Example output

```
  precaching:
    spec:
      platformImage: quay.io/openshift-release-dev/ocp-
release@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1
ef
      operatorsIndexes:
        - registry.example.com:5000/custom-redhat-operators:1.0.0
      operatorsPackagesAndChannels:
        - local-storage-operator: stable
        - ptp-operator: stable
        - sriov-network-operator: stable
      excludePrecachePatterns:
        - aws
        - vsphere
      additionalImages:
        -
quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d38
08fc925ada29c559a47e2e1ef
        -
quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d38
08fc925ada29c559a47adfaef
        -
quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafd
```

```
edga0991234afdadfsa09
      spaceRequired: "30"
    status:
      sno1: Starting
      sno2: Starting
```

The pre-caching configurations are validated by checking if the managed policies exist. Valid configurations of the **ClusterGroupUpgrade** and the **PreCachingConfig** CRs result in the following statuses:

Example output of valid CRs

```
- lastTransitionTime: "2023-01-01T00:00:01Z"
  message: All selected clusters are valid
  reason: ClusterSelectionCompleted
  status: "True"
  type: ClusterSelected
- lastTransitionTime: "2023-01-01T00:00:02Z"
  message: Completed validation
  reason: ValidationCompleted
  status: "True"
  type: Validated
- lastTransitionTime: "2023-01-01T00:00:03Z"
  message: Precaching spec is valid and consistent
  reason: PrecacheSpecIsWellFormed
  status: "True"
  type: PrecacheSpecValid
- lastTransitionTime: "2023-01-01T00:00:04Z"
  message: Precaching in progress for 1 clusters
  reason: InProgress
  status: "False"
  type: PrecachingSucceeded
```

Example of an invalid PreCachingConfig CR

```
Type:    "PrecacheSpecValid"
Status:  False,
Reason:  "PrecacheSpecIncomplete"
Message: "Precaching spec is incomplete: failed to get PreCachingConfig resource due to
PreCachingConfig.ran.openshift.io "<pre-caching_cr_name>" not found"
```

2. You can find the pre-caching job by running the following command on the managed cluster:

```
$ oc get jobs -n openshift-talo-pre-cache
```

Example of pre-caching job in progress

```
NAME        COMPLETIONS       DURATION      AGE
pre-cache   0/1               1s            1s
```

3. You can check the status of the pod created for the pre-caching job by running the following command:

```
$ oc describe pod pre-cache -n openshift-talo-pre-cache
```

Example of pre-caching job in progress

```
Type      Reason            Age    From              Message
Normal    SuccesfulCreate   19s    job-controller    Created pod: pre-cache-abcd1
```

4. You can get live updates on the status of the job by running the following command:

```
$ oc logs -f pre-cache-abcd1 -n openshift-talo-pre-cache
```

5. To verify the pre-cache job is successfully completed, run the following command:

```
$ oc describe pod pre-cache -n openshift-talo-pre-cache
```

Example of completed pre-cache job

```
Type      Reason            Age    From              Message
Normal    SuccesfulCreate   5m19s  job-controller    Created pod: pre-cache-abcd1
Normal    Completed         19s    job-controller    Job completed
```

6. To verify that the images are successfully pre-cached on the single-node OpenShift, do the following:

   a. Enter into the node in debug mode:

   ```
   $ oc debug node/cnfdf00.example.lab
   ```

   b. Change root to **host**:

   ```
   $ chroot /host/
   ```

   c. Search for the desired images:

   ```
   $ sudo podman images | grep <operator_name>
   ```

Additional resources

- For more information about the TALM precaching workflow, see Using the container image precache feature.

9.3.8. About the auto-created ClusterGroupUpgrade CR for GitOps ZTP

TALM has a controller called **ManagedClusterForCGU** that monitors the **Ready** state of the **ManagedCluster** CRs on the hub cluster and creates the **ClusterGroupUpgrade** CRs for GitOps Zero Touch Provisioning (ZTP).

For any managed cluster in the **Ready** state without a **ztp-done** label applied, the **ManagedClusterForCGU** controller automatically creates a **ClusterGroupUpgrade** CR in the **ztp-install** namespace with its associated RHACM policies that are created during the GitOps ZTP process. TALM then remediates the set of configuration policies that are listed in the auto-created **ClusterGroupUpgrade** CR to push the configuration CRs to the managed cluster.

If there are no policies for the managed cluster at the time when the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR with no policies is created. Upon completion of the **ClusterGroupUpgrade** the managed cluster is labeled as **ztp-done**. If there are policies that you want to apply for that managed cluster, manually create a **ClusterGroupUpgrade** as a day-2 operation.

Example of an auto-created **ClusterGroupUpgrade** CR for GitOps ZTP

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  generation: 1
  name: spoke1
  namespace: ztp-install
  ownerReferences:
  - apiVersion: cluster.open-cluster-management.io/v1
    blockOwnerDeletion: true
    controller: true
    kind: ManagedCluster
    name: spoke1
    uid: 98fdb9b2-51ee-4ee7-8f57-a84f7f35b9d5
  resourceVersion: "46666836"
  uid: b8be9cd2-764f-4a62-87d6-6b767852c7da
spec:
  actions:
    afterCompletion:
      addClusterLabels:
        ztp-done: "" (1)
      deleteClusterLabels:
        ztp-running: ""
      deleteObjects: true
    beforeEnable:
      addClusterLabels:
        ztp-running: "" (2)
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - common-spoke1-config-policy
  - common-spoke1-subscriptions-policy
  - group-spoke1-config-policy
  - spoke1-config-policy
  - group-spoke1-validator-du-policy
  preCaching: false
  remediationStrategy:
    maxConcurrency: 1
    timeout: 240
```

1. Applied to the managed cluster when TALM completes the cluster configuration.
2. Applied to the managed cluster when TALM starts deploying the configuration policies.

CHAPTER 10. MANAGING CLUSTER POLICES WITH POLICYGENTEMPLATE RESOURCES

10.1. CONFIGURING MANAGED CLUSTER POLICIES BY USING POLICYGENTEMPLATE RESOURCES

Applied **Policy** custom resources (CRs) configure the managed clusters that you provision. You can customize how Red Hat Advanced Cluster Management (RHACM) uses **PolicyGenTemplate** CRs to generate the applied **Policy** CRs.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

10.1.1. About the PolicyGenTemplate CRD

The **PolicyGenTemplate** custom resource definition (CRD) tells the **PolicyGen** policy generator what custom resources (CRs) to include in the cluster configuration, how to combine the CRs into the generated policies, and what items in those CRs need to be updated with overlay content.

The following example shows a **PolicyGenTemplate** CR (**common-du-ranGen.yaml**) extracted from the **ztp-site-generate** reference container. The **common-du-ranGen.yaml** file defines two Red Hat Advanced Cluster Management (RHACM) policies. The polices manage a collection of configuration CRs, one for each unique value of **policyName** in the CR. **common-du-ranGen.yaml** creates a single placement binding and a placement rule to bind the policies to clusters based on the labels listed in the **spec.bindingRules** section.

Example PolicyGenTemplate CR - common-ranGen.yaml

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "common-latest"
  namespace: "ztp-common"
spec:
  bindingRules:
    common: "true" (1)
    du-profile: "latest"
  sourceFiles: (2)
    - fileName: SriovSubscriptionNS.yaml
      policyName: "subscriptions-policy"
    - fileName: SriovSubscriptionOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: SriovSubscription.yaml
      policyName: "subscriptions-policy"
    - fileName: SriovOperatorStatus.yaml
      policyName: "subscriptions-policy"
    - fileName: PtpSubscriptionNS.yaml
      policyName: "subscriptions-policy"
    - fileName: PtpSubscriptionOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: PtpSubscription.yaml
      policyName: "subscriptions-policy"
    - fileName: PtpOperatorStatus.yaml
      policyName: "subscriptions-policy"
    - fileName: ClusterLogNS.yaml
      policyName: "subscriptions-policy"
    - fileName: ClusterLogOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: ClusterLogSubscription.yaml
      policyName: "subscriptions-policy"
    - fileName: ClusterLogOperatorStatus.yaml
      policyName: "subscriptions-policy"
    - fileName: StorageNS.yaml
      policyName: "subscriptions-policy"
    - fileName: StorageOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: StorageSubscription.yaml
      policyName: "subscriptions-policy"
    - fileName: StorageOperatorStatus.yaml
      policyName: "subscriptions-policy"
    - fileName: DefaultCatsrc.yaml (3)
      policyName: "config-policy" (4)
      metadata:
        name: redhat-operators-disconnected
      spec:
        displayName: disconnected-redhat-operators
        image: registry.example.com:5000/disconnected-redhat-operators/disconnected-redhat-
operator-index:v4.9
    - fileName: DisconnectedICSP.yaml
      policyName: "config-policy"
      spec:
        repositoryDigestMirrors:
        - mirrors:
          - registry.example.com:5000
          source: registry.redhat.io
```

1. **common: "true"** applies the policies to all clusters with this label.

2. Files listed under **sourceFiles** create the Operator policies for installed clusters.

3. **DefaultCatsrc.yaml** configures the catalog source for the disconnected registry.

4. **policyName: "config-policy"** configures Operator subscriptions. The **OperatorHub** CR disables the default and this CR replaces **redhat-operators** with a **CatalogSource** CR that points to the disconnected registry.

A **PolicyGenTemplate** CR can be constructed with any number of included CRs. Apply the following example CR in the hub cluster to generate a policy containing a single CR:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "group-du-sno"
  namespace: "ztp-group"
spec:
  bindingRules:
    group-du-sno: ""
  mcp: "master"
  sourceFiles:
    - fileName: PtpConfigSlave.yaml
      policyName: "config-policy"
      metadata:
        name: "du-ptp-slave"
      spec:
        profile:
        - name: "slave"
          interface: "ens5f0"
          ptp4lOpts: "-2 -s --summary_interval -4"
          phc2sysOpts: "-a -r -n 24"
```

Using the source file **PtpConfigSlave.yaml** as an example, the file defines a **PtpConfig** CR. The generated policy for the **PtpConfigSlave** example is named **group-du-sno-config-policy**. The **PtpConfig** CR defined in the generated **group-du-sno-config-policy** is named **du-ptp-slave**. The **spec** defined in **PtpConfigSlave.yaml** is placed under **du-ptp-slave** along with the other **spec** items defined under the source file.

The following example shows the **group-du-sno-config-policy** CR:

```
apiVersion: policy.open-cluster-management.io/v1
kind: Policy
metadata:
  name: group-du-ptp-config-policy
  namespace: groups-sub
  annotations:
    policy.open-cluster-management.io/categories: CM Configuration Management
    policy.open-cluster-management.io/controls: CM-2 Baseline Configuration
    policy.open-cluster-management.io/standards: NIST SP 800-53
spec:
    remediationAction: inform
    disabled: false
    policy-templates:
        - objectDefinition:
            apiVersion: policy.open-cluster-management.io/v1
            kind: ConfigurationPolicy
            metadata:
                name: group-du-ptp-config-policy-config
            spec:
                remediationAction: inform
                severity: low
                namespaceselector:
                    exclude:
```

```
          - kube-*
        include:
          - '*'
      object-templates:
        - complianceType: musthave
          objectDefinition:
            apiVersion: ptp.openshift.io/v1
            kind: PtpConfig
            metadata:
              name: du-ptp-slave
              namespace: openshift-ptp
            spec:
              recommend:
                - match:
                - nodeLabel: node-role.kubernetes.io/worker-du
                  priority: 4
                  profile: slave
              profile:
                - interface: ens5f0
                  name: slave
                  phc2sysOpts: -a -r -n 24
                  ptp4lConf: |
                    [global]
                    #
                    # Default Data Set
                    #
                    twoStepFlag 1
                    slaveOnly 0
                    priority1 128
                    priority2 128
                    domainNumber 24
```

10.1.2. Recommendations when customizing PolicyGenTemplate CRs

Consider the following best practices when customizing site configuration **PolicyGenTemplate** custom resources (CRs):

- Use as few policies as are necessary. Using fewer policies requires less resources. Each additional policy creates increased CPU load for the hub cluster and the deployed managed cluster. CRs are combined into policies based on the **policyName** field in the **PolicyGenTemplate** CR. CRs in the same **PolicyGenTemplate** which have the same value for **policyName** are managed under a single policy.

- In disconnected environments, use a single catalog source for all Operators by configuring the registry as a single index containing all Operators. Each additional **CatalogSource** CR on the managed clusters increases CPU usage.

- **MachineConfig** CRs should be included as **extraManifests** in the **SiteConfig** CR so that they are applied during installation. This can reduce the overall time taken until the cluster is ready to deploy applications.

- **PolicyGenTemplate** CRs should override the channel field to explicitly identify the desired version. This ensures that changes in the source CR during upgrades does not update the generated subscription.

Additional resources

- For recommendations about scaling clusters with RHACM, see Performance and scalability.

NOTE

When managing large numbers of spoke clusters on the hub cluster, minimize the number of policies to reduce resource consumption.

Grouping multiple configuration CRs into a single or limited number of policies is one way to reduce the overall number of policies on the hub cluster. When using the common, group, and site hierarchy of policies for managing site configuration, it is especially important to combine site-specific configurations into a single policy.

10.1.3. PolicyGenTemplate CRs for RAN deployments

Use **PolicyGenTemplate** custom resources (CRs) to customize the configuration applied to the cluster by using the GitOps Zero Touch Provisioning (ZTP) pipeline. The **PolicyGenTemplate** CR allows you to generate one or more policies to manage the set of configuration CRs on your fleet of clusters. The **PolicyGenTemplate** CR identifies the set of managed CRs, bundles them into policies, builds the policy wrapping around those CRs, and associates the policies with clusters by using label binding rules.

The reference configuration, obtained from the GitOps ZTP container, is designed to provide a set of critical features and node tuning settings that ensure the cluster can support the stringent performance and resource utilization constraints typical of RAN (Radio Access Network) Distributed Unit (DU) applications. Changes or omissions from the baseline configuration can affect feature availability, performance, and resource utilization. Use the reference **PolicyGenTemplate** CRs as the basis to create a hierarchy of configuration files tailored to your specific site requirements.

The baseline **PolicyGenTemplate** CRs that are defined for RAN DU cluster configuration can be extracted from the GitOps ZTP **ztp-site-generate** container. See "Preparing the GitOps ZTP site configuration repository" for further details.

The **PolicyGenTemplate** CRs can be found in the **./out/argocd/example/policygentemplates** folder. The reference architecture has common, group, and site-specific configuration CRs. Each **PolicyGenTemplate** CR refers to other CRs that can be found in the **./out/source-crs** folder.

The **PolicyGenTemplate** CRs relevant to RAN cluster configuration are described below. Variants are provided for the group **PolicyGenTemplate** CRs to account for differences in single-node, three-node compact, and standard cluster configurations. Similarly, site-specific configuration variants are provided for single-node clusters and multi-node (compact or standard) clusters. Use the group and site-specific configuration variants that are relevant for your deployment.

Table 10.1. PolicyGenTemplate CRs for RAN deployments

PolicyGenTemplate CR	Description
example-multinode-site.yaml	Contains a set of CRs that get applied to multi-node clusters. These CRs configure SR-IOV features typical for RAN installations.
example-sno-site.yaml	Contains a set of CRs that get applied to single-node OpenShift clusters. These CRs configure SR-IOV features typical for RAN installations.

PolicyGenTemplate CR	Description
common-mno-ranGen.yaml	Contains a set of common RAN policy configuration that get applied to multi-node clusters.
common-ranGen.yaml	Contains a set of common RAN CRs that get applied to all clusters. These CRs subscribe to a set of operators providing cluster features typical for RAN as well as baseline cluster tuning.
group-du-3node-ranGen.yaml	Contains the RAN policies for three-node clusters only.
group-du-sno-ranGen.yaml	Contains the RAN policies for single-node clusters only.
group-du-standard-ranGen.yaml	Contains the RAN policies for standard three control-plane clusters.
group-du-3node-validator-ranGen.yaml	**PolicyGenTemplate** CR used to generate the various policies required for three-node clusters.
group-du-standard-validator-ranGen.yaml	**PolicyGenTemplate** CR used to generate the various policies required for standard clusters.
group-du-sno-validator-ranGen.yaml	**PolicyGenTemplate** CR used to generate the various policies required for single-node OpenShift clusters.

Additional resources

- Preparing the GitOps ZTP site configuration repository

10.1.4. Customizing a managed cluster with PolicyGenTemplate CRs

Use the following procedure to customize the policies that get applied to the managed cluster that you provision using the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You configured the hub cluster for generating the required installation and policy CRs.
- You created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the Argo CD application.

Procedure

1. Create a **PolicyGenTemplate** CR for site-specific configuration CRs.
   a. Choose the appropriate example for your CR from the **out/argocd/example/policygentemplates** folder, for example, **example-sno-site.yaml** or **example-multinode-site.yaml**.
   b. Change the **spec.bindingRules** field in the example file to match the site-specific label included in the **SiteConfig** CR. In the example **SiteConfig** file, the site-specific label is **sites: example-sno**.

      NOTE

      Ensure that the labels defined in your **PolicyGenTemplate spec.bindingRules** field correspond to the labels that are defined in the related managed clusters **SiteConfig** CR.

   c. Change the content in the example file to match the desired configuration.
2. Optional: Create a **PolicyGenTemplate** CR for any common configuration CRs that apply to the entire fleet of clusters.
   a. Select the appropriate example for your CR from the **out/argocd/example/policygentemplates** folder, for example, **common-ranGen.yaml**.
   b. Change the content in the example file to match the required configuration.
3. Optional: Create a **PolicyGenTemplate** CR for any group configuration CRs that apply to the certain groups of clusters in the fleet.
   Ensure that the content of the overlaid spec files matches your required end state. As a reference, the **out/source-crs** directory contains the full list of source-crs available to be included and overlaid by your PolicyGenTemplate templates.

   NOTE

   Depending on the specific requirements of your clusters, you might need more than a single group policy per cluster type, especially considering that the example group policies each have a single **PerformancePolicy.yaml** file that can only be shared across a set of clusters if those clusters consist of identical hardware configurations.

   a. Select the appropriate example for your CR from the **out/argocd/example/policygentemplates** folder, for example, **group-du-sno-ranGen.yaml**.
   b. Change the content in the example file to match the required configuration.
4. Optional. Create a validator inform policy **PolicyGenTemplate** CR to signal when the GitOps ZTP installation and configuration of the deployed cluster is complete. For more information, see "Creating a validator inform policy".
5. Define all the policy namespaces in a YAML file similar to the example **out/argocd/example/policygentemplates/ns.yaml** file.

IMPORTANT

Do not include the **Namespace** CR in the same file with the **PolicyGenTemplate** CR.

6. Add the **PolicyGenTemplate** CRs and **Namespace** CR to the **kustomization.yaml** file in the generators section, similar to the example shown in **out/argocd/example/policygentemplateskustomization.yaml**.

7. Commit the **PolicyGenTemplate** CRs, **Namespace** CR, and associated **kustomization.yaml** file in your Git repository and push the changes.
   The ArgoCD pipeline detects the changes and begins the managed cluster deployment. You can push the changes to the **SiteConfig** CR and the **PolicyGenTemplate** CR simultaneously.

Additional resources

- Signalling GitOps ZTP cluster deployment completion with validator inform policies

10.1.5. Monitoring managed cluster policy deployment progress

The ArgoCD pipeline uses **PolicyGenTemplate** CRs in Git to generate the RHACM policies and then sync them to the hub cluster. You can monitor the progress of the managed cluster policy synchronization after the assisted service installs OpenShift Container Platform on the managed cluster.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. The Topology Aware Lifecycle Manager (TALM) applies the configuration policies that are bound to the cluster.
   After the cluster installation is complete and the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR corresponding to this cluster, with a list of ordered policies defined by the **ran.openshift.io/ztp-deploy-wave annotations**, is automatically created by the TALM. The cluster's policies are applied in the order listed in **ClusterGroupUpgrade** CR.

   You can monitor the high-level progress of configuration policy reconciliation by using the following commands:

   ```
   $ export CLUSTER=<clusterName>
   ```

   ```
   $ oc get clustergroupupgrades -n ztp-install $CLUSTER -o jsonpath='{.status.conditions[-1:]}'
   | jq
   ```

   #### Example output

   ```
   {
     "lastTransitionTime": "2022-11-09T07:28:09Z",
     "message": "Remediating non-compliant policies",
     "reason": "InProgress",
   ```

```
  "status": "True",
  "type": "Progressing"
}
```

2. You can monitor the detailed cluster policy compliance status by using the RHACM dashboard or the command line.

   a. To check policy compliance by using **oc**, run the following command:

      ```
      $ oc get policies -n $CLUSTER
      ```

      Example output

      ```
      NAME                                                    REMEDIATION ACTION   COMPLIANCE STATE
      AGE
      ztp-common.common-config-policy                                inform            Compliant
      3h42m
      ztp-common.common-subscriptions-policy                         inform            NonCompliant
      3h42m
      ztp-group.group-du-sno-config-policy                        inform            NonCompliant
      3h42m
      ztp-group.group-du-sno-validator-du-policy                  inform            NonCompliant
      3h42m
      ztp-install.example1-common-config-policy-pjz9s         enforce           Compliant
      167m
      ztp-install.example1-common-subscriptions-policy-zzd9k   enforce           NonCompliant
      164m
      ztp-site.example1-config-policy                             inform            NonCompliant      3h42m
      ztp-site.example1-perf-policy                               inform            NonCompliant      3h42m
      ```

   b. To check policy status from the RHACM web console, perform the following actions:

      i. Click **Governance → Find policies**.

      ii. Click on a cluster policy to check its status.

When all of the cluster policies become compliant, GitOps ZTP installation and configuration for the cluster is complete. The **ztp-done** label is added to the cluster.

In the reference configuration, the final policy that becomes compliant is the one defined in the ***-du-validator-policy** policy. This policy, when compliant on a cluster, ensures that all cluster configuration, Operator installation, and Operator configuration is complete.

10.1.6. Validating the generation of configuration policy CRs

Policy custom resources (CRs) are generated in the same namespace as the **PolicyGenTemplate** from which they are created. The same troubleshooting flow applies to all policy CRs generated from a **PolicyGenTemplate** regardless of whether they are **ztp-common**, **ztp-group**, or **ztp-site** based, as shown using the following commands:

```
$ export NS=<namespace>
```

```
$ oc get policy -n $NS
```

The expected set of policy-wrapped CRs should be displayed.

If the policies failed synchronization, use the following troubleshooting steps.

Procedure

1. To display detailed information about the policies, run the following command:

```
$ oc describe -n openshift-gitops application policies
```

2. Check for **Status: Conditions:** to show the error logs. For example, setting an invalid **sourceFile** entry to **fileName:** generates the error shown below:

```
Status:
  Conditions:
    Last Transition Time:  2021-11-26T17:21:39Z
    Message:               rpc error: code = Unknown desc = `kustomize build
/tmp/https___git.com/ran-sites/policies/ --enable-alpha-plugins` failed exit status 1:
2021/11/26 17:21:40 Error could not find test.yaml under source-crs/: no such file or directory
Error: failure in plugin configured via /tmp/kust-plugin-config-52463179; exit status 1: exit
status 1
    Type:  ComparisonError
```

3. Check for **Status: Sync:**. If there are log errors at **Status: Conditions:**, the **Status: Sync:** shows **Unknown** or **Error**:

```
Status:
  Sync:
    Compared To:
      Destination:
        Namespace:  policies-sub
        Server:     https://kubernetes.default.svc
      Source:
        Path:             policies
        Repo URL:         https://git.com/ran-sites/policies/.git
        Target Revision:  master
    Status:               Error
```

4. When Red Hat Advanced Cluster Management (RHACM) recognizes that policies apply to a **ManagedCluster** object, the policy CR objects are applied to the cluster namespace. Check to see if the policies were copied to the cluster namespace:

```
$ oc get policy -n $CLUSTER
```

Example output:

```
NAME                                         REMEDIATION ACTION   COMPLIANCE STATE   AGE
ztp-common.common-config-policy              inform               Compliant          13d
ztp-common.common-subscriptions-policy       inform               Compliant          13d
ztp-group.group-du-sno-config-policy         inform               Compliant          13d
ztp-group.group-du-sno-validator-du-policy   inform               Compliant          13d
ztp-site.example-sno-config-policy           inform               Compliant          13d
```

RHACM copies all applicable policies into the cluster namespace. The copied policy names have the format: **<PolicyGenTemplate.Namespace>.<PolicyGenTemplate.Name>-<policyName>**.

5. Check the placement rule for any policies not copied to the cluster namespace. The **matchSelector** in the **PlacementRule** for those policies should match labels on the **ManagedCluster** object:

```
$ oc get PlacementRule -n $NS
```

6. Note the **PlacementRule** name appropriate for the missing policy, common, group, or site, using the following command:

```
$ oc get PlacementRule -n $NS <placement_rule_name> -o yaml
```

   - The status-decisions should include your cluster name.
   - The key-value pair of the **matchSelector** in the spec must match the labels on your managed cluster.

7. Check the labels on the **ManagedCluster** object by using the following command:

```
$ oc get ManagedCluster $CLUSTER -o jsonpath='{.metadata.labels}' | jq
```

8. Check to see what policies are compliant by using the following command:

```
$ oc get policy -n $CLUSTER
```

If the **Namespace**, **OperatorGroup**, and **Subscription** policies are compliant but the Operator configuration policies are not, it is likely that the Operators did not install on the managed cluster. This causes the Operator configuration policies to fail to apply because the CRD is not yet applied to the spoke.

10.1.7. Restarting policy reconciliation

You can restart policy reconciliation when unexpected compliance issues occur, for example, when the **ClusterGroupUpgrade** custom resource (CR) has timed out.

Procedure

1. A **ClusterGroupUpgrade** CR is generated in the namespace **ztp-install** by the Topology Aware Lifecycle Manager after the managed cluster becomes **Ready**:

```
$ export CLUSTER=<clusterName>
```

```
$ oc get clustergroupupgrades -n ztp-install $CLUSTER
```

2. If there are unexpected issues and the policies fail to become complaint within the configured timeout (the default is 4 hours), the status of the **ClusterGroupUpgrade** CR shows **UpgradeTimedOut**:

```
$ oc get clustergroupupgrades -n ztp-install $CLUSTER -o jsonpath='{.status.conditions[?(@.type=="Ready")]}'
```

3. A **ClusterGroupUpgrade** CR in the **UpgradeTimedOut** state automatically restarts its policy reconciliation every hour. If you have changed your policies, you can start a retry immediately by deleting the existing **ClusterGroupUpgrade** CR. This triggers the automatic creation of a new **ClusterGroupUpgrade** CR that begins reconciling the policies immediately:

```
$ oc delete clustergroupupgrades -n ztp-install $CLUSTER
```

Note that when the **ClusterGroupUpgrade** CR completes with status **UpgradeCompleted** and the managed cluster has the label **ztp-done** applied, you can make additional configuration changes by using **PolicyGenTemplate**. Deleting the existing **ClusterGroupUpgrade** CR will not make the TALM generate a new CR.

At this point, GitOps ZTP has completed its interaction with the cluster and any further interactions should be treated as an update and a new **ClusterGroupUpgrade** CR created for remediation of the policies.

Additional resources

- For information about using Topology Aware Lifecycle Manager (TALM) to construct your own **ClusterGroupUpgrade** CR, see About the ClusterGroupUpgrade CR.

10.1.8. Changing applied managed cluster CRs using policies

You can remove content from a custom resource (CR) that is deployed in a managed cluster through a policy.

By default, all **Policy** CRs created from a **PolicyGenTemplate** CR have the **complianceType** field set to **musthave**. A **musthave** policy without the removed content is still compliant because the CR on the managed cluster has all the specified content. With this configuration, when you remove content from a CR, TALM removes the content from the policy but the content is not removed from the CR on the managed cluster.

With the **complianceType** field to **mustonlyhave**, the policy ensures that the CR on the cluster is an exact match of what is specified in the policy.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have deployed a managed cluster from a hub cluster running RHACM.
- You have installed Topology Aware Lifecycle Manager on the hub cluster.

Procedure

1. Remove the content that you no longer need from the affected CRs. In this example, the **disableDrain: false** line was removed from the **SriovOperatorConfig** CR.

   Example CR

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovOperatorConfig
metadata:
  name: default
  namespace: openshift-sriov-network-operator
spec:
  configDaemonNodeSelector:
    "node-role.kubernetes.io/$mcp": ""
  disableDrain: true
  enableInjector: true
  enableOperatorWebhook: true
```

2. Change the **complianceType** of the affected policies to **mustonlyhave** in the **group-du-sno-ranGen.yaml** file.

   Example YAML

   ```
   - fileName: SriovOperatorConfig.yaml
     policyName: "config-policy"
     complianceType: mustonlyhave
   ```

3. Create a **ClusterGroupUpdates** CR and specify the clusters that must receive the CR changes::

   Example ClusterGroupUpdates CR

   ```
   apiVersion: ran.openshift.io/v1alpha1
   kind: ClusterGroupUpgrade
   metadata:
     name: cgu-remove
     namespace: default
   spec:
     managedPolicies:
       - ztp-group.group-du-sno-config-policy
     enable: false
     clusters:
     - spoke1
     - spoke2
     remediationStrategy:
       maxConcurrency: 2
       timeout: 240
     batchTimeoutAction:
   ```

4. Create the **ClusterGroupUpgrade** CR by running the following command:

   ```
   $ oc create -f cgu-remove.yaml
   ```

5. When you are ready to apply the changes, for example, during an appropriate maintenance window, change the value of the **spec.enable** field to **true** by running the following command:

   ```
   $ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-remove \
   --patch '{"spec":{"enable":true}}' --type=merge
   ```

Verification

1. Check the status of the policies by running the following command:

```
$ oc get <kind> <changed_cr_name>
```

Example output

```
NAMESPACE   NAME                                              REMEDIATION ACTION
COMPLIANCE STATE   AGE
default     cgu-ztp-group.group-du-sno-config-policy           enforce                          17m
default     ztp-group.group-du-sno-config-policy              inform            NonCompliant
15h
```

When the **COMPLIANCE STATE** of the policy is **Compliant**, it means that the CR is updated and the unwanted content is removed.

2. Check that the policies are removed from the targeted clusters by running the following command on the managed clusters:

```
$ oc get <kind> <changed_cr_name>
```

If there are no results, the CR is removed from the managed cluster.

10.1.9. Indication of done for GitOps ZTP installations

GitOps Zero Touch Provisioning (ZTP) simplifies the process of checking the GitOps ZTP installation status for a cluster. The GitOps ZTP status moves through three phases: cluster installation, cluster configuration, and GitOps ZTP done.

Cluster installation phase

The cluster installation phase is shown by the **ManagedClusterJoined** and **ManagedClusterAvailable** conditions in the **ManagedCluster** CR . If the **ManagedCluster** CR does not have these conditions, or the condition is set to **False**, the cluster is still in the installation phase. Additional details about installation are available from the **AgentClusterInstall** and **ClusterDeployment** CRs. For more information, see "Troubleshooting GitOps ZTP".

Cluster configuration phase

The cluster configuration phase is shown by a **ztp-running** label applied the **ManagedCluster** CR for the cluster.

GitOps ZTP done

Cluster installation and configuration is complete in the GitOps ZTP done phase. This is shown by the removal of the **ztp-running** label and addition of the **ztp-done** label to the **ManagedCluster** CR. The **ztp-done** label shows that the configuration has been applied and the baseline DU configuration has completed cluster tuning.
The change to the GitOps ZTP done state is conditional on the compliant state of a Red Hat Advanced Cluster Management (RHACM) validator inform policy. This policy captures the existing criteria for a completed installation and validates that it moves to a compliant state only when GitOps ZTP provisioning of the managed cluster is complete.

The validator inform policy ensures the configuration of the cluster is fully applied and Operators have completed their initialization. The policy validates the following:

- The target **MachineConfigPool** contains the expected entries and has finished updating. All nodes are available and not degraded.
- The SR-IOV Operator has completed initialization as indicated by at least one **SriovNetworkNodeState** with **syncStatus: Succeeded**.

- The PTP Operator daemon set exists.

10.2. ADVANCED MANAGED CLUSTER CONFIGURATION WITH POLICYGENTEMPLATE RESOURCES

You can use **PolicyGenTemplate** CRs to deploy custom functionality in your managed clusters.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

10.2.1. Deploying additional changes to clusters

If you require cluster configuration changes outside of the base GitOps Zero Touch Provisioning (ZTP) pipeline configuration, there are three options:

Apply the additional configuration after the GitOps ZTP pipeline is complete

When the GitOps ZTP pipeline deployment is complete, the deployed cluster is ready for application workloads. At this point, you can install additional Operators and apply configurations specific to your requirements. Ensure that additional configurations do not negatively affect the performance of the platform or allocated CPU budget.

Add content to the GitOps ZTP library

The base source custom resources (CRs) that you deploy with the GitOps ZTP pipeline can be augmented with custom content as required.

Create extra manifests for the cluster installation

Extra manifests are applied during installation and make the installation process more efficient.

IMPORTANT

Providing additional source CRs or modifying existing source CRs can significantly impact the performance or CPU profile of OpenShift Container Platform.

10.2.2. Using PolicyGenTemplate CRs to override source CRs content

PolicyGenTemplate custom resources (CRs) allow you to overlay additional configuration details on top of the base source CRs provided with the GitOps plugin in the **ztp-site-generate** container. You can think of **PolicyGenTemplate** CRs as a logical merge or patch to the base CR. Use **PolicyGenTemplate** CRs to update a single field of the base CR, or overlay the entire contents of the base CR. You can update values and insert fields that are not in the base CR.

The following example procedure describes how to update fields in the generated **PerformanceProfile** CR for the reference configuration based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml** file. Use the procedure as a basis for modifying other parts of the **PolicyGenTemplate** based on your requirements.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for Argo CD.

Procedure

1. Review the baseline source CR for existing content. You can review the source CRs listed in the reference **PolicyGenTemplate** CRs by extracting them from the GitOps Zero Touch Provisioning (ZTP) container.

   a. Create an /**out** folder:

   ```
   $ mkdir -p ./out
   ```

   b. Extract the source CRs:

   ```
   $ podman run --log-driver=none --rm registry.redhat.io/openshift4/ztp-site-generate-rhel8:v4.16.1 extract /home/ztp --tar | tar x -C ./out
   ```

2. Review the baseline **PerformanceProfile** CR in **./out/source-crs/PerformanceProfile.yaml**:

```
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
  name: $name
  annotations:
    ran.openshift.io/ztp-deploy-wave: "10"
spec:
  additionalKernelArgs:
  - "idle=poll"
  - "rcupdate.rcu_normal_after_boot=0"
  cpu:
    isolated: $isolated
    reserved: $reserved
  hugepages:
    defaultHugepagesSize: $defaultHugepagesSize
    pages:
      - size: $size
        count: $count
        node: $node
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/$mcp: ""
  net:
    userLevelNetworking: true
  nodeSelector:
    node-role.kubernetes.io/$mcp: ''
  numa:
```

```
    topologyPolicy: "restricted"
  realTimeKernel:
    enabled: true
```

NOTE

Any fields in the source CR which contain **$…** are removed from the generated CR if they are not provided in the **PolicyGenTemplate** CR.

3. Update the **PolicyGenTemplate** entry for **PerformanceProfile** in the **group-du-sno-ranGen.yaml** reference file. The following example **PolicyGenTemplate** CR stanza supplies appropriate CPU specifications, sets the **hugepages** configuration, and adds a new field that sets **globallyDisableIrqLoadBalancing** to false.

```
- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
    name: openshift-node-performance-profile
  spec:
    cpu:
      # These must be tailored for the specific hardware platform
      isolated: "2-19,22-39"
      reserved: "0-1,20-21"
    hugepages:
      defaultHugepagesSize: 1G
      pages:
        - size: 1G
          count: 10
    globallyDisableIrqLoadBalancing: false
```

4. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP argo CD application.

Example output

The GitOps ZTP application generates an RHACM policy that contains the generated **PerformanceProfile** CR. The contents of that CR are derived by merging the **metadata** and **spec** contents from the **PerformanceProfile** entry in the **PolicyGenTemplate** onto the source CR. The resulting CR has the following content:

```
---
apiVersion: performance.openshift.io/v2
kind: PerformanceProfile
metadata:
    name: openshift-node-performance-profile
spec:
    additionalKernelArgs:
        - idle=poll
        - rcupdate.rcu_normal_after_boot=0
    cpu:
        isolated: 2-19,22-39
        reserved: 0-1,20-21
    globallyDisableIrqLoadBalancing: false
    hugepages:
        defaultHugepagesSize: 1G
    pages:
      - count: 10
        size: 1G
  machineConfigPoolSelector:
    pools.operator.machineconfiguration.openshift.io/master: ""
  net:
    userLevelNetworking: true
  nodeSelector:
    node-role.kubernetes.io/master: ""
  numa:
    topologyPolicy: restricted
  realTimeKernel:
    enabled: true
```

NOTE

In the /**source-crs** folder that you extract from the **ztp-site-generate** container, the **$** syntax is not used for template substitution as implied by the syntax. Rather, if the **policyGen** tool sees the **$** prefix for a string and you do not specify a value for that field in the related **PolicyGenTemplate** CR, the field is omitted from the output CR entirely.

An exception to this is the **$mcp** variable in **/source-crs** YAML files that is substituted with the specified value for **mcp** from the **PolicyGenTemplate** CR. For example, in **example/policygentemplates/group-du-standard-ranGen.yaml**, the value for **mcp** is **worker**:

```
spec:
  bindingRules:
    group-du-standard: ""
  mcp: "worker"
```

The **policyGen** tool replace instances of **$mcp** with **worker** in the output CRs.

10.2.3. Adding custom content to the GitOps ZTP pipeline

Perform the following procedure to add new content to the GitOps ZTP pipeline.

Procedure

1. Create a subdirectory named **source-crs** in the directory that contains the **kustomization.yaml** file for the **PolicyGenTemplate** custom resource (CR).

2. Add your user-provided CRs to the **source-crs** subdirectory, as shown in the following example:

```
example
└── policygentemplates
    ├── dev.yaml
    ├── kustomization.yaml
    ├── mec-edge-sno1.yaml
    ├── sno.yaml
    └── source-crs (1)
        ├── PaoCatalogSource.yaml
        ├── PaoSubscription.yaml
        ├── custom-crs
    |   ├── apiserver-config.yaml
    |   └── disable-nic-lldp.yaml
    └── elasticsearch
        ├── ElasticsearchNS.yaml
        └── ElasticsearchOperatorGroup.yaml
```

1 The **source-crs** subdirectory must be in the same directory as the **kustomization.yaml** file.

3. Update the required **PolicyGenTemplate** CRs to include references to the content you added in the **source-crs/custom-crs** and **source-crs/elasticsearch** directories. For example:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "group-dev"
  namespace: "ztp-clusters"
spec:
  bindingRules:
    dev: "true"
  mcp: "master"
  sourceFiles:
    # These policies/CRs come from the internal container Image
    #Cluster Logging
    - fileName: ClusterLogNS.yaml
      remediationAction: inform
      policyName: "group-dev-cluster-log-ns"
    - fileName: ClusterLogOperGroup.yaml
      remediationAction: inform
      policyName: "group-dev-cluster-log-operator-group"
    - fileName: ClusterLogSubscription.yaml
      remediationAction: inform
      policyName: "group-dev-cluster-log-sub"
    #Local Storage Operator
    - fileName: StorageNS.yaml
      remediationAction: inform
      policyName: "group-dev-lso-ns"
    - fileName: StorageOperGroup.yaml
      remediationAction: inform
      policyName: "group-dev-lso-operator-group"
    - fileName: StorageSubscription.yaml
      remediationAction: inform
      policyName: "group-dev-lso-sub"
    #These are custom local polices that come from the source-crs directory in the git repo
    # Performance Addon Operator
    - fileName: PaoSubscriptionNS.yaml
      remediationAction: inform
      policyName: "group-dev-pao-ns"
    - fileName: PaoSubscriptionCatalogSource.yaml
      remediationAction: inform
      policyName: "group-dev-pao-cat-source"
      spec:
        image: <container_image_url>
    - fileName: PaoSubscription.yaml
      remediationAction: inform
    policyName: "group-dev-pao-sub"
  #Elasticsearch Operator
  - fileName: elasticsearch/ElasticsearchNS.yaml (1)
    remediationAction: inform
    policyName: "group-dev-elasticsearch-ns"
  - fileName: elasticsearch/ElasticsearchOperatorGroup.yaml
    remediationAction: inform
    policyName: "group-dev-elasticsearch-operator-group"
  #Custom Resources
  - fileName: custom-crs/apiserver-config.yaml (2)
    remediationAction: inform
    policyName: "group-dev-apiserver-config"
  - fileName: custom-crs/disable-nic-lldp.yaml
    remediationAction: inform
    policyName: "group-dev-disable-nic-lldp"
```

(1) (2) Set **fileName** to include the relative path to the file from the **/source-crs** parent directory.

4. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository that is monitored by the GitOps ZTP Argo CD policies application.

5. Update the **ClusterGroupUpgrade** CR to include the changed **PolicyGenTemplate** and save it as **cgu-test.yaml**. The following example shows a generated **cgu-test.yaml** file.

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: custom-source-cr
  namespace: ztp-clusters
spec:
  managedPolicies:
    - group-dev-config-policy
  enable: true
  clusters:
  - cluster1
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
```

6. Apply the updated **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f cgu-test.yaml
```

Verification

- Check that the updates have succeeded by running the following command:

```
$ oc get cgu -A
```

Example output

```
NAMESPACE     NAME               AGE   STATE        DETAILS
ztp-clusters  custom-source-cr   6s    InProgress   Remediating non-compliant policies
```

```
ztp-install   cluster1          19h   Completed    All clusters are compliant with all the managed
policies
```

10.2.4. Configuring policy compliance evaluation timeouts for PolicyGenTemplate CRs

Use Red Hat Advanced Cluster Management (RHACM) installed on a hub cluster to monitor and report on whether your managed clusters are compliant with applied policies. RHACM uses policy templates to apply predefined policy controllers and policies. Policy controllers are Kubernetes custom resource definition (CRD) instances.

You can override the default policy evaluation intervals with **PolicyGenTemplate** custom resources (CRs). You configure duration settings that define how long a **ConfigurationPolicy** CR can be in a state of policy compliance or non-compliance before RHACM re-evaluates the applied cluster policies.

The GitOps Zero Touch Provisioning (ZTP) policy generator generates **ConfigurationPolicy** CR policies with pre-defined policy evaluation intervals. The default value for the **noncompliant** state is 10 seconds. The default value for the **compliant** state is 10 minutes. To disable the evaluation interval, set the value to **never**.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. To configure the evaluation interval for all policies in a **PolicyGenTemplate** CR, set appropriate **compliant** and **noncompliant** values for the **evaluationInterval** field. For example:

```
spec:
  evaluationInterval:
    compliant: 30m
    noncompliant: 20s
```

NOTE

You can also set **compliant** and **noncompliant** fields to **never** to stop evaluating the policy after it reaches particular compliance state.

2. To configure the evaluation interval for an individual policy object in a **PolicyGenTemplate** CR, add the **evaluationInterval** field and set appropriate values. For example:

```
spec:
  sourceFiles:
    - fileName: SriovSubscription.yaml
      policyName: "sriov-sub-policy"
      evaluationInterval:
        compliant: never
        noncompliant: 10s
```

3. Commit the **PolicyGenTemplate** CRs files in the Git repository and push your changes.

Verification

Check that the managed spoke cluster policies are monitored at the expected intervals.

1. Log in as a user with **cluster-admin** privileges on the managed cluster.

2. Get the pods that are running in the **open-cluster-management-agent-addon** namespace. Run the following command:

```
$ oc get pods -n open-cluster-management-agent-addon
```

Example output

```
NAME                                         READY   STATUS    RESTARTS        AGE
config-policy-controller-858b894c68-v4xdb    1/1     Running   22 (5d8h ago)   10d
```

3. Check the applied policies are being evaluated at the expected interval in the logs for the **config-policy-controller** pod:

```
$ oc logs -n open-cluster-management-agent-addon config-policy-controller-858b894c68-
v4xdb
```

Example output

```
2022-05-10T15:10:25.280Z       info   configuration-policy-controller
controllers/configurationpolicy_controller.go:166      Skipping the policy evaluation due to the
policy not reaching the evaluation interval  {"policy": "compute-1-config-policy-config"}
2022-05-10T15:10:25.280Z       info   configuration-policy-controller
controllers/configurationpolicy_controller.go:166      Skipping the policy evaluation due to the
policy not reaching the evaluation interval  {"policy": "compute-1-common-compute-1-catalog-
policy-config"}
```

10.2.5. Signalling GitOps ZTP cluster deployment completion with validator inform policies

Create a validator inform policy that signals when the GitOps Zero Touch Provisioning (ZTP) installation and configuration of the deployed cluster is complete. This policy can be used for deployments of single-node OpenShift clusters, three-node clusters, and standard clusters.

Procedure

1. Create a standalone **PolicyGenTemplate** custom resource (CR) that contains the source file **validatorCRs/informDuValidator.yaml**. You only need one standalone **PolicyGenTemplate** CR for each cluster type. For example, this CR applies a validator inform policy for single-node OpenShift clusters:

Example single-node cluster validator inform policy CR (group-du-sno-validator-ranGen.yaml)

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
```

```
metadata:
  name: "group-du-sno-validator" 1
  namespace: "ztp-group" 2
spec:
  bindingRules:
    group-du-sno: "" 3
  bindingExcludedRules:
    ztp-done: "" 4
  mcp: "master" 5
  sourceFiles:
    - fileName: validatorCRs/informDuValidator.yaml
      remediationAction: inform 6
      policyName: "du-policy" 7
```

1. The name of the **{policy-gen-crs}** object. This name is also used as part of the names for the **placementBinding**, **placementRule**, and **policy** that are created in the requested **namespace**.
2. This value should match the **namespace** used in the group **policy-gen-crs**.
3. The **group-du-*** label defined in **bindingRules** must exist in the **SiteConfig** files.
4. The label defined in **bindingExcludedRules** must be`ztp-done:`. The **ztp-done** label is used in coordination with the Topology Aware Lifecycle Manager.
5. **mcp** defines the **MachineConfigPool** object that is used in the source file **validatorCRs/informDuValidator.yaml**. It should be **master** for single node and three-node cluster deployments and **worker** for standard cluster deployments.
6. Optional. The default value is **inform**.
7. This value is used as part of the name for the generated RHACM policy. The generated validator policy for the single node example is **group-du-sno-validator-du-policy**.

2. Commit the **PolicyGenTemplate** CR file in your Git repository and push the changes.

Additional resources

- Upgrading GitOps ZTP

10.2.6. Configuring power states using PolicyGenTemplate CRs

For low latency and high-performance edge deployments, it is necessary to disable or limit C-states and P-states. With this configuration, the CPU runs at a constant frequency, which is typically the maximum turbo frequency. This ensures that the CPU is always running at its maximum speed, which results in high performance and low latency. This leads to the best latency for workloads. However, this also leads to the highest power consumption, which might not be necessary for all workloads.

Workloads can be classified as critical or non-critical, with critical workloads requiring disabled C-state and P-state settings for high performance and low latency, while non-critical workloads use C-state and P-state settings for power savings at the expense of some latency and performance. You can configure the following three power states using GitOps Zero Touch Provisioning (ZTP):

- High-performance mode provides ultra low latency at the highest power consumption.

- Performance mode provides low latency at a relatively high power consumption.
- Power saving balances reduced power consumption with increased latency.

The default configuration is for a low latency, performance mode.

PolicyGenTemplate custom resources (CRs) allow you to overlay additional configuration details onto the base source CRs provided with the GitOps plugin in the **ztp-site-generate** container.

Configure the power states by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml**.

The following common prerequisites apply to configuring all three power states.

Prerequisites

- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for Argo CD.
- You have followed the procedure described in "Preparing the GitOps ZTP site configuration repository".

Additional resources

- Configuring node power consumption and realtime processing with workload hints

10.2.6.1. Configuring performance mode using PolicyGenTemplate CRs

Follow this example to set performance mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml**.

Performance mode provides low latency at a relatively high power consumption.

Prerequisites

- You have configured the BIOS with performance related settings by following the guidance in "Configuring host firmware for low latency and high performance".

Procedure

1. Update the **PolicyGenTemplate** entry for **PerformanceProfile** in the **group-du-sno-ranGen.yaml** reference file in **out/argocd/example/policygentemplates//** as follows to set performance mode.

```
- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
  # ...
  spec:
    # ...
    workloadHints:
      realTime: true
      highPowerConsumption: false
      perPodPowerManagement: false
```

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

10.2.6.2. Configuring high-performance mode using PolicyGenTemplate CRs

Follow this example to set high performance mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml**.

High performance mode provides ultra low latency at the highest power consumption.

Prerequisites

- You have configured the BIOS with performance related settings by following the guidance in "Configuring host firmware for low latency and high performance".

Procedure

1. Update the **PolicyGenTemplate** entry for **PerformanceProfile** in the **group-du-sno-ranGen.yaml** reference file in **out/argocd/example/policygentemplates/** as follows to set high-performance mode.

```
- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
  # ...
  spec:
  # ...
    workloadHints:
      realTime: true
      highPowerConsumption: true
      perPodPowerManagement: false
```

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

10.2.6.3. Configuring power saving mode using PolicyGenTemplate CRs

Follow this example to set power saving mode by updating the **workloadHints** fields in the generated **PerformanceProfile** CR for the reference configuration, based on the **PolicyGenTemplate** CR in the **group-du-sno-ranGen.yaml**.

The power saving mode balances reduced power consumption with increased latency.

Prerequisites

- You enabled C-states and OS-controlled P-states in the BIOS.

Procedure

1. Update the **PolicyGenTemplate** entry for **PerformanceProfile** in the **group-du-sno-ranGen.yaml** reference file in **out/argocd/example/policygentemplates/** as follows to configure power saving mode. It is recommended to configure the CPU governor for the power saving mode through the additional kernel arguments object.

```
- fileName: PerformanceProfile.yaml
  policyName: "config-policy"
  metadata:
  # ...
  spec:
    # ...
    workloadHints:
      realTime: true
      highPowerConsumption: false
      perPodPowerManagement: true
    # ...
    additionalKernelArgs:
      - # ...
      - "cpufreq.default_governor=schedutil" (1)
```

(1) The **schedutil** governor is recommended, however, other governors that can be used include **ondemand** and **powersave**.

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

Verification

1. Select a worker node in your deployed cluster from the list of nodes identified by using the following command:

```
$ oc get nodes
```

2. Log in to the node by using the following command:

```
$ oc debug node/<node-name>
```

Replace **<node-name>** with the name of the node you want to verify the power state on.

3. Set **/host** as the root directory within the debug shell. The debug pod mounts the host's root file system in **/host** within the pod. By changing the root directory to **/host**, you can run binaries contained in the host's executable paths as shown in the following example:

```
# chroot /host
```

4. Run the following command to verify the applied power state:

```
# cat /proc/cmdline
```

Expected output

- For power saving mode the **intel_pstate=passive**.

Additional resources

- Configuring power saving for nodes that run colocated high and low priority workloads
- Configuring host firmware for low latency and high performance
- Preparing the GitOps ZTP site configuration repository

10.2.6.4. Maximizing power savings

Limiting the maximum CPU frequency is recommended to achieve maximum power savings. Enabling C-states on the non-critical workload CPUs without restricting the maximum CPU frequency negates much of the power savings by boosting the frequency of the critical CPUs.

Maximize power savings by updating the **sysfs** plugin fields, setting an appropriate value for **max_perf_pct** in the **TunedPerformancePatch** CR for the reference configuration. This example based on the **group-du-sno-ranGen.yaml** describes the procedure to follow to restrict the maximum CPU frequency.

Prerequisites

- You have configured power savings mode as described in "Using PolicyGenTemplate CRs to configure power savings mode".

Procedure

1. Update the **PolicyGenTemplate** entry for **TunedPerformancePatch** in the **group-du-sno-ranGen.yaml** reference file in **out/argocd/example/policygentemplates/**. To maximize power savings, add **max_perf_pct** as shown in the following example:

```
- fileName: TunedPerformancePatch.yaml
  policyName: "config-policy"
  spec:
    profile:
      - name: performance-patch
        data: |
          # ...
          [sysfs]
          /sys/devices/system/cpu/intel_pstate/max_perf_pct=<x> 1
```

1 The **max_perf_pct** controls the maximum frequency the **cpufreq** driver is allowed to set as a percentage of the maximum supported CPU frequency. This value applies to all CPUs. You can check the maximum supported frequency in **/sys/devices/system/cpu/cpu0/cpufreq/cpuinfo_max_freq**. As a starting point, you can use a percentage that caps all CPUs at the **All Cores Turbo** frequency. The **All Cores Turbo** frequency is the frequency that all cores will run at when the cores are all fully occupied.

NOTE

To maximize power savings, set a lower value. Setting a lower value for **max_perf_pct** limits the maximum CPU frequency, thereby reducing power consumption, but also potentially impacting performance. Experiment with different values and monitor the system's performance and power consumption to find the optimal setting for your use-case.

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP Argo CD application.

10.2.7. Configuring LVM Storage using PolicyGenTemplate CRs

You can configure Logical Volume Manager (LVM) Storage for managed clusters that you deploy with GitOps Zero Touch Provisioning (ZTP).

NOTE

You use LVM Storage to persist event subscriptions when you use PTP events or bare-metal hardware events with HTTP transport.

Use the Local Storage Operator for persistent storage that uses local volumes in distributed units.

Prerequisites

- Install the OpenShift CLI (**oc**).
- Log in as a user with **cluster-admin** privileges.
- Create a Git repository where you manage your custom site configuration data.

Procedure

1. To configure LVM Storage for new managed clusters, add the following YAML to **spec.sourceFiles** in the **common-ranGen.yaml** file:

```
- fileName: StorageLVMOSubscriptionNS.yaml
  policyName: subscription-policies
- fileName: StorageLVMOSubscriptionOperGroup.yaml
  policyName: subscription-policies
- fileName: StorageLVMOSubscription.yaml
  spec:
    name: lvms-operator
    channel: stable-4.16
  policyName: subscription-policies
```

NOTE

The Storage LVMO subscription is deprecated. In future releases of OpenShift Container Platform, the storage LVMO subscription will not be available. Instead, you must use the Storage LVMS subscription.

In OpenShift Container Platform 4.16, you can use the Storage LVMS subscription instead of the LVMO subscription. The LVMS subscription does not require manual overrides in the **common-ranGen.yaml** file. Add the following YAML to **spec.sourceFiles** in the **common-ranGen.yaml** file to use the Storage LVMS subscription:

```
- fileName: StorageLVMSubscriptionNS.yaml
  policyName: subscription-policies
- fileName: StorageLVMSubscriptionOperGroup.yaml
  policyName: subscription-policies
- fileName: StorageLVMSubscription.yaml
  policyName: subscription-policies
```

2. Add the **LVMCluster** CR to **spec.sourceFiles** in your specific group or individual site configuration file. For example, in the **group-du-sno-ranGen.yaml** file, add the following:

```
- fileName: StorageLVMCluster.yaml
  policyName: "lvms-config"
  spec:
    storage:
      deviceClasses:
      - name: vg1
        thinPoolConfig:
          name: thin-pool-1
          sizePercent: 90
          overprovisionRatio: 10
```

This example configuration creates a volume group (**vg1**) with all the available devices, except the disk where OpenShift Container Platform is installed. A thin-pool logical volume is also created.

3. Merge any other required changes and files with your custom site repository.

4. Commit the **PolicyGenTemplate** changes in Git, and then push the changes to your site configuration repository to deploy LVM Storage to new sites using GitOps ZTP.

10.2.8. Configuring PTP events with PolicyGenTemplate CRs

You can use the GitOps ZTP pipeline to configure PTP events that use HTTP or AMQP transport.

NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, Red Hat AMQ Interconnect support status.

10.2.8.1. Configuring PTP events that use HTTP transport

You can configure PTP events that use HTTP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. Apply the following **PolicyGenTemplate** changes to **group-du-3node-ranGen.yaml**, **group-du-sno-ranGen.yaml**, or **group-du-standard-ranGen.yaml** files according to your requirements:

   a. In **spec.sourceFiles**, add the **PtpOperatorConfig** CR file that configures the transport host:

```
- fileName: PtpOperatorConfigForEvent.yaml
  policyName: "config-policy"
  spec:
    daemonNodeSelector: {}
    ptpEventConfig:
      enableEventPublisher: true
      transportHost: http://ptp-event-publisher-service-NODE_NAME.openshift-
ptp.svc.cluster.local:9043
```

NOTE

In OpenShift Container Platform 4.13 or later, you do not need to set the **transportHost** field in the **PtpOperatorConfig** resource when you use HTTP transport with PTP events.

   b. Configure the **linuxptp** and **phc2sys** for the PTP clock type and interface. For example, add the following YAML into **spec.sourceFiles**:

```
- fileName: PtpConfigSlave.yaml (1)
  policyName: "config-policy"
  metadata:
    name: "du-ptp-slave"
  spec:
    profile:
    - name: "slave"
      interface: "ens5f1" (2)
      ptp4lOpts: "-2 -s --summary_interval -4" (3)
      phc2sysOpts: "-a -r -m -n 24 -N 8 -R 16" (4)
    ptpClockThreshold: (5)
      holdOverTimeout: 30 # seconds
      maxOffsetThreshold: 100  # nano seconds
      minOffsetThreshold: -100
```

1. Can be one of **PtpConfigMaster.yaml**, **PtpConfigSlave.yaml**, or **PtpConfigSlaveCvl.yaml** depending on your requirements. **PtpConfigSlaveCvl.yaml** configures **linuxptp** services for an Intel E810 Columbiaville NIC. For configurations based on **group-du-sno-ranGen.yaml** or **group-du-3node-ranGen.yaml**, use **PtpConfigSlave.yaml**.

2. Device specific interface name.

3. You must append the **--summary_interval -4** value to **ptp4lOpts** in **.spec.sourceFiles.spec.profile** to enable PTP fast events.

4. Required **phc2sysOpts** values. **-m** prints messages to **stdout**. The **linuxptp-daemon** **DaemonSet** parses the logs and generates Prometheus metrics.

5. Optional. If the **ptpClockThreshold** stanza is not present, default values are used for the **ptpClockThreshold** fields. The stanza shows default **ptpClockThreshold** values. The **ptpClockThreshold** values configure how long after the PTP master clock is disconnected before PTP events are triggered. **holdOverTimeout** is the time value in seconds before the PTP clock event state changes to **FREERUN** when the PTP master clock is disconnected. The **maxOffsetThreshold** and **minOffsetThreshold** settings configure offset values in nanoseconds that compare against the values for **CLOCK_REALTIME** (**phc2sys**) or master offset (**ptp4l**). When the **ptp4l** or **phc2sys** offset value is outside this range, the PTP clock state is set to **FREERUN**. When the offset value is within this range, the PTP clock state is set to **LOCKED**.

2. Merge any other required changes and files with your custom site repository.

3. Push the changes to your site configuration repository to deploy PTP fast events to new sites using GitOps ZTP.

Additional resources

- Using PolicyGenTemplate CRs to override source CRs content

10.2.8.2. Configuring PTP events that use AMQP transport

You can configure PTP events that use AMQP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, Red Hat AMQ Interconnect support status.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. Add the following YAML into **spec.sourceFiles** in the **common-ranGen.yaml** file to configure the AMQP Operator:

```
#AMQ interconnect operator for fast events
- fileName: AmqSubscriptionNS.yaml
  policyName: "subscriptions-policy"
- fileName: AmqSubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: AmqSubscription.yaml
  policyName: "subscriptions-policy"
```

2. Apply the following **PolicyGenTemplate** changes to **group-du-3node-ranGen.yaml**, **group-du-sno-ranGen.yaml**, or **group-du-standard-ranGen.yaml** files according to your requirements:

   a. In **spec.sourceFiles**, add the **PtpOperatorConfig** CR file that configures the AMQ transport host to the **config-policy**:

   ```
   - fileName: PtpOperatorConfigForEvent.yaml
     policyName: "config-policy"
     spec:
       daemonNodeSelector: {}
       ptpEventConfig:
         enableEventPublisher: true
         transportHost: "amqp://amq-router.amq-router.svc.cluster.local"
   ```

   b. Configure the **linuxptp** and **phc2sys** for the PTP clock type and interface. For example, add the following YAML into **spec.sourceFiles**:

   ```
   - fileName: PtpConfigSlave.yaml 1
     policyName: "config-policy"
     metadata:
       name: "du-ptp-slave"
     spec:
       profile:
       - name: "slave"
         interface: "ens5f1" 2
         ptp4lOpts: "-2 -s --summary_interval -4" 3
         phc2sysOpts: "-a -r -m -n 24 -N 8 -R 16" 4
       ptpClockThreshold: 5
         holdOverTimeout: 30 # seconds
         maxOffsetThreshold: 100  # nano seconds
         minOffsetThreshold: -100
   ```

   1 Can be one of **PtpConfigMaster.yaml**, **PtpConfigSlave.yaml**, or **PtpConfigSlaveCvl.yaml** depending on your requirements. **PtpConfigSlaveCvl.yaml** configures **linuxptp** services for an Intel E810 Columbiaville NIC. For configurations based on **group-du-sno-ranGen.yaml** or **group-du-3node-ranGen.yaml**, use **PtpConfigSlave.yaml**.

   2 Device specific interface name.

   3 You must append the **--summary_interval -4** value to **ptp4lOpts** in

.spec.sourceFiles.spec.profile to enable PTP fast events.

4 Required **phc2sysOpts** values. **-m** prints messages to **stdout**. The **linuxptp-daemon DaemonSet** parses the logs and generates Prometheus metrics.

5 Optional. If the **ptpClockThreshold** stanza is not present, default values are used for the **ptpClockThreshold** fields. The stanza shows default **ptpClockThreshold** values. The **ptpClockThreshold** values configure how long after the PTP master clock is disconnected before PTP events are triggered. **holdOverTimeout** is the time value in seconds before the PTP clock event state changes to **FREERUN** when the PTP master clock is disconnected. The **maxOffsetThreshold** and **minOffsetThreshold** settings configure offset values in nanoseconds that compare against the values for **CLOCK_REALTIME** (**phc2sys**) or master offset (**ptp4l**). When the **ptp4l** or **phc2sys** offset value is outside this range, the PTP clock state is set to **FREERUN**. When the offset value is within this range, the PTP clock state is set to **LOCKED**.

3. Apply the following **PolicyGenTemplate** changes to your specific site YAML files, for example, **example-sno-site.yaml**:

   a. In **spec.sourceFiles**, add the **Interconnect** CR file that configures the AMQ router to the **config-policy**:

   ```
   - fileName: AmqInstance.yaml
     policyName: "config-policy"
   ```

4. Merge any other required changes and files with your custom site repository.

5. Push the changes to your site configuration repository to deploy PTP fast events to new sites using GitOps ZTP.

Additional resources

- Installing the AMQ messaging bus
- OpenShift image registry overview

10.2.9. Configuring bare-metal events with PolicyGenTemplate CRs

You can use the GitOps ZTP pipeline to configure bare-metal events that use HTTP or AMQP transport.

NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, Red Hat AMQ Interconnect support status.

10.2.9.1. Configuring bare-metal events that use HTTP transport

You can configure bare-metal events that use HTTP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. Configure the Bare Metal Event Relay Operator by adding the following YAML to **spec.sourceFiles** in the **common-ranGen.yaml** file:

```yaml
# Bare Metal Event Relay Operator
- fileName: BareMetalEventRelaySubscriptionNS.yaml
  policyName: "subscriptions-policy"
- fileName: BareMetalEventRelaySubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: BareMetalEventRelaySubscription.yaml
  policyName: "subscriptions-policy"
```

2. Add the **HardwareEvent** CR to **spec.sourceFiles** in your specific group configuration file, for example, in the **group-du-sno-ranGen.yaml** file:

```yaml
- fileName: HardwareEvent.yaml (1)
  policyName: "config-policy"
  spec:
    nodeSelector: {}
    transportHost: "http://hw-event-publisher-service.openshift-bare-metal-events.svc.cluster.local:9043"
    logLevel: "info"
```

(1) Each baseboard management controller (BMC) requires a single **HardwareEvent** CR only.

NOTE

In OpenShift Container Platform 4.13 or later, you do not need to set the **transportHost** field in the **HardwareEvent** custom resource (CR) when you use HTTP transport with bare-metal events.

3. Merge any other required changes and files with your custom site repository.

4. Push the changes to your site configuration repository to deploy bare-metal events to new sites with GitOps ZTP.

5. Create the Redfish Secret by running the following command:

```
$ oc -n openshift-bare-metal-events create secret generic redfish-basic-auth \
--from-literal=username=<bmc_username> --from-literal=password=<bmc_password> \
--from-literal=hostaddr="<bmc_host_ip_addr>"
```

Additional resources

- Installing the Bare Metal Event Relay using the CLI
- Creating the bare-metal event and Secret CRs

10.2.9.2. Configuring bare-metal events that use AMQP transport

You can configure bare-metal events that use AMQP transport on managed clusters that you deploy with the GitOps Zero Touch Provisioning (ZTP) pipeline.

NOTE

HTTP transport is the default transport for PTP and bare-metal events. Use HTTP transport instead of AMQP for PTP and bare-metal events where possible. AMQ Interconnect is EOL from 30 June 2024. Extended life cycle support (ELS) for AMQ Interconnect ends 29 November 2029. For more information see, Red Hat AMQ Interconnect support status.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data.

Procedure

1. To configure the AMQ Interconnect Operator and the Bare Metal Event Relay Operator, add the following YAML to **spec.sourceFiles** in the **common-ranGen.yaml** file:

```
# AMQ Interconnect Operator for fast events
- fileName: AmqSubscriptionNS.yaml
  policyName: "subscriptions-policy"
- fileName: AmqSubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: AmqSubscription.yaml
  policyName: "subscriptions-policy"
# Bare Metal Event Relay Operator
- fileName: BareMetalEventRelaySubscriptionNS.yaml
  policyName: "subscriptions-policy"
- fileName: BareMetalEventRelaySubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
- fileName: BareMetalEventRelaySubscription.yaml
  policyName: "subscriptions-policy"
```

2. Add the **Interconnect** CR to **spec.sourceFiles** in the site configuration file, for example, the **example-sno-site.yaml** file:

```
- fileName: AmqInstance.yaml
  policyName: "config-policy"
```

3. Add the **HardwareEvent** CR to **spec.sourceFiles** in your specific group configuration file, for example, in the **group-du-sno-ranGen.yaml** file:

```
- path: HardwareEvent.yaml
  patches:
    nodeSelector: {}
    transportHost: "amqp://<amq_interconnect_name>.
<amq_interconnect_namespace>.svc.cluster.local" 1
    logLevel: "info"
```

1 The **transportHost** URL is composed of the existing AMQ Interconnect CR **name** and **namespace**. For example, in **transportHost: "amqp://amq-router.amq-router.svc.cluster.local"**, the AMQ Interconnect **name** and **namespace** are both set to **amq-router**.

NOTE

Each baseboard management controller (BMC) requires a single **HardwareEvent** resource only.

4. Commit the **PolicyGenTemplate** change in Git, and then push the changes to your site configuration repository to deploy bare-metal events monitoring to new sites using GitOps ZTP.

5. Create the Redfish Secret by running the following command:

```
$ oc -n openshift-bare-metal-events create secret generic redfish-basic-auth \
--from-literal=username=<bmc_username> --from-literal=password=<bmc_password> \
--from-literal=hostaddr="<bmc_host_ip_addr>"
```

10.2.10. Configuring the Image Registry Operator for local caching of images

OpenShift Container Platform manages image caching using a local registry. In edge computing use cases, clusters are often subject to bandwidth restrictions when communicating with centralized image registries, which might result in long image download times.

Long download times are unavoidable during initial deployment. Over time, there is a risk that CRI-O will erase the **/var/lib/containers/storage** directory in the case of an unexpected shutdown. To address long image download times, you can create a local image registry on remote managed clusters using GitOps Zero Touch Provisioning (ZTP). This is useful in Edge computing scenarios where clusters are deployed at the far edge of the network.

Before you can set up the local image registry with GitOps ZTP, you need to configure disk partitioning in the **SiteConfig** CR that you use to install the remote managed cluster. After installation, you configure the local image registry using a **PolicyGenTemplate** CR. Then, the GitOps ZTP pipeline creates Persistent Volume (PV) and Persistent Volume Claim (PVC) CRs and patches the **imageregistry** configuration.

NOTE

The local image registry can only be used for user application images and cannot be used for the OpenShift Container Platform or Operator Lifecycle Manager operator images.

Additional resources

- OpenShift Container Platform registry overview

10.2.10.1. Configuring disk partitioning with SiteConfig

Configure disk partitioning for a managed cluster using a **SiteConfig** CR and GitOps Zero Touch Provisioning (ZTP). The disk partition details in the **SiteConfig** CR must match the underlying disk.

IMPORTANT

You must complete this procedure at installation time.

Prerequisites

- Install Butane.

Procedure

1. Create the **storage.bu** file.

```
variant: fcos
version: 1.3.0
storage:
  disks:
  - device: /dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0 (1)
    wipe_table: false
    partitions:
    - label: var-lib-containers
      start_mib: <start_of_partition> (2)
      size_mib: <partition_size> (3)
  filesystems:
    - path: /var/lib/containers
      device: /dev/disk/by-partlabel/var-lib-containers
      format: xfs
      wipe_filesystem: true
      with_mount_unit: true
      mount_options:
        - defaults
        - prjquota
```

(1) Specify the root disk.

(2) Specify the start of the partition in MiB. If the value is too small, the installation fails.

(3) Specify the size of the partition. If the value is too small, the deployments fails.

2. Convert the **storage.bu** to an Ignition file by running the following command:

```
$ butane storage.bu
```

Example output

```
{"ignition":{"version":"3.2.0"},"storage":{"disks":[{"device":"/dev/disk/by-path/pci-0000:01:00.0-
scsi-0:2:0:0","partitions":[{"label":"var-lib-
containers","sizeMiB":0,"startMiB":250000}],"wipeTable":false}],"filesystems":
[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":
```

```
["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}]},"systemd":{"units":
[{"contents":"# # Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-
fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}
```

3. Use a tool such as JSON Pretty Print to convert the output into JSON format.

4. Copy the output into the **.spec.clusters.nodes.ignitionConfigOverride** field in the **SiteConfig** CR.

Example

```
[...]
spec:
  clusters:
    - nodes:
        - ignitionConfigOverride: |
          {
            "ignition": {
              "version": "3.2.0"
            },
            "storage": {
              "disks": [
                {
                  "device": "/dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0",
                  "partitions": [
                    {
                      "label": "var-lib-containers",
                      "sizeMiB": 0,
                      "startMiB": 250000
                    }
                  ],
                  "wipeTable": false
                }
              ],
              "filesystems": [
                {
                  "device": "/dev/disk/by-partlabel/var-lib-containers",
                  "format": "xfs",
                  "mountOptions": [
                    "defaults",
                    "prjquota"
                  ],
                  "path": "/var/lib/containers",
                  "wipeFilesystem": true
                }
              ]
            },
            "systemd": {
              "units": [
                {
                  "contents": "# # Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-fs.target",
                  "enabled": true,
                  "name": "var-lib-containers.mount"
                }
              ]
            }
          }
[...]
```

NOTE

If the **.spec.clusters.nodes.ignitionConfigOverride** field does not exist, create it.

Verification

1. During or after installation, verify on the hub cluster that the **BareMetalHost** object shows the annotation by running the following command:

```
$ oc get bmh -n my-sno-ns my-sno -ojson | jq '.metadata.annotations["bmac.agent-
install.openshift.io/ignition-config-overrides"]
```

Example output

```
"{\"ignition\":{\"version\":\"3.2.0\"},\"storage\":{\"disks\":[{\"device\":\"/dev/disk/by-id/wwn-
0x6b07b250ebb9d0002a33509f24af1f62\",\"partitions\":[{\"label\":\"var-lib-
containers\",\"sizeMiB\":0,\"startMiB\":250000}],\"wipeTable\":false}],\"filesystems\":
[{\"device\":\"/dev/disk/by-partlabel/var-lib-containers\",\"format\":\"xfs\",\"mountOptions\":
[\"defaults\",\"prjquota\"],\"path\":\"/var/lib/containers\",\"wipeFilesystem\":true}]},\"systemd\":
{\"units\":[{\"contents\":\"# Generated by Butane\\n[Unit]\\nRequires=systemd-fsck@dev-disk-
by\\\\x2dpartlabel-var\\\\x2dlib\\\\x2dcontainers.service\\nAfter=systemd-fsck@dev-disk-
by\\\\x2dpartlabel-
var\\\\x2dlib\\\\x2dcontainers.service\\n\\n[Mount]\\nWhere=/var/lib/containers\\nWhat=/dev/disk/
by-partlabel/var-lib-
containers\\nType=xfs\\nOptions=defaults,prjquota\\n\\n[Install]\\nRequiredBy=local-
fs.target\",\"enabled\":true,\"name\":\"var-lib-containers.mount\"}]}}"
```

2. After installation, check the single-node OpenShift disk status.

   a. Enter into a debug session on the single-node OpenShift node by running the following command. This step instantiates a debug pod called **<node_name>-debug**:

   ```
   $ oc debug node/my-sno-node
   ```

   b. Set /**host** as the root directory within the debug shell by running the following command. The debug pod mounts the host's root file system in /**host** within the pod. By changing the root directory to /**host**, you can run binaries contained in the host's executable paths:

   ```
   # chroot /host
   ```

c. List information about all available block devices by running the following command:

```
# lsblk
```

Example output

```
NAME   MAJ:MIN RM   SIZE RO TYPE MOUNTPOINTS
sda      8:0    0 446.6G  0 disk
├─sda1   8:1    0     1M  0 part
├─sda2   8:2    0   127M  0 part
├─sda3   8:3    0   384M  0 part /boot
├─sda4   8:4    0 243.6G  0 part /var
│                                /sysroot/ostree/deploy/rhcos/var
│                                /usr
│                                /etc
│                                /
│                                /sysroot
└─sda5   8:5    0 202.5G  0 part /var/lib/containers
```

d. Display information about the file system disk space usage by running the following command:

```
# df -h
```

Example output

```
Filesystem      Size  Used Avail Use% Mounted on
devtmpfs        4.0M     0  4.0M   0% /dev
tmpfs           126G   84K  126G   1% /dev/shm
tmpfs            51G   93M   51G   1% /run
/dev/sda4       244G  5.2G  239G   3% /sysroot
tmpfs           126G  4.0K  126G   1% /tmp
/dev/sda5       203G  119G   85G  59% /var/lib/containers
/dev/sda3       350M  110M  218M  34% /boot
tmpfs            26G     0   26G   0% /run/user/1000
```

10.2.10.2. Configuring the image registry using PolicyGenTemplate CRs

Use **PolicyGenTemplate** (PGT) CRs to apply the CRs required to configure the image registry and patch the **imageregistry** configuration.

Prerequisites

- You have configured a disk partition in the managed cluster.
- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data for use with GitOps Zero Touch Provisioning (ZTP).

Procedure

1. Configure the storage class, persistent volume claim, persistent volume, and image registry configuration in the appropriate **PolicyGenTemplate** CR. For example, to configure an individual site, add the following YAML to the file **example-sno-site.yaml**:

```
sourceFiles:
  # storage class
  - fileName: StorageClass.yaml
    policyName: "sc-for-image-registry"
    metadata:
      name: image-registry-sc
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100" (1)
  # persistent volume claim
  - fileName: StoragePVC.yaml
    policyName: "pvc-for-image-registry"
    metadata:
      name: image-registry-pvc
      namespace: openshift-image-registry
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100"
    spec:
      accessModes:
        - ReadWriteMany
      resources:
        requests:
          storage: 100Gi
      storageClassName: image-registry-sc
      volumeMode: Filesystem
  # persistent volume
  - fileName: ImageRegistryPV.yaml (2)
    policyName: "pv-for-image-registry"
    metadata:
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100"
  - fileName: ImageRegistryConfig.yaml
    policyName: "config-for-image-registry"
    complianceType: musthave
    metadata:
      annotations:
        ran.openshift.io/ztp-deploy-wave: "100"
    spec:
      storage:
        pvc:
          claim: "image-registry-pvc"
```

1. Set the appropriate value for **ztp-deploy-wave** depending on whether you are configuring image registries at the site, common, or group level. **ztp-deploy-wave: "100"** is suitable for development or testing because it allows you to group the referenced source files together.

2. In **ImageRegistryPV.yaml**, ensure that the **spec.local.path** field is set to **/var/imageregistry** to match the value set for the **mount_point** field in the **SiteConfig** CR.

IMPORTANT

Do not set **complianceType: mustonlyhave** for the **- fileName: ImageRegistryConfig.yaml** configuration. This can cause the registry pod deployment to fail.

2. Commit the **PolicyGenTemplate** change in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.

Verification

Use the following steps to troubleshoot errors with the local image registry on the managed clusters:

- Verify successful login to the registry while logged in to the managed cluster. Run the following commands:

  a. Export the managed cluster name:

  ```
  $ cluster=<managed_cluster_name>
  ```

  b. Get the managed cluster **kubeconfig** details:

  ```
  $ oc get secret -n $cluster $cluster-admin-password -o jsonpath='{.data.password}' |
  base64 -d > kubeadmin-password-$cluster
  ```

  c. Download and export the cluster **kubeconfig**:

  ```
  $ oc get secret -n $cluster $cluster-admin-kubeconfig -o jsonpath='{.data.kubeconfig}' |
  base64 -d > kubeconfig-$cluster && export KUBECONFIG=./kubeconfig-$cluster
  ```

  d. Verify access to the image registry from the managed cluster. See "Accessing the registry".

- Check that the **Config** CRD in the **imageregistry.operator.openshift.io** group instance is not reporting errors. Run the following command while logged in to the managed cluster:

  ```
  $ oc get image.config.openshift.io cluster -o yaml
  ```

  #### Example output

  ```
  apiVersion: config.openshift.io/v1
  kind: Image
  metadata:
    annotations:
      include.release.openshift.io/ibm-cloud-managed: "true"
      include.release.openshift.io/self-managed-high-availability: "true"
      include.release.openshift.io/single-node-developer: "true"
      release.openshift.io/create-only: "true"
    creationTimestamp: "2021-10-08T19:02:39Z"
    generation: 5
    name: cluster
    resourceVersion: "688678648"
    uid: 0406521b-39c0-4cda-ba75-873697da75a4
  spec:
    additionalTrustedCA:
      name: acm-ice
  ```

- Check that the **PersistentVolumeClaim** on the managed cluster is populated with data. Run the following command while logged in to the managed cluster:

```
$ oc get pv image-registry-sc
```

- Check that the **registry*** pod is running and is located under the **openshift-image-registry** namespace.

```
$ oc get pods -n openshift-image-registry | grep registry*
```

Example output

```
cluster-image-registry-operator-68f5c9c589-42cfg   1/1     Running     0          8d
image-registry-5f8987879-6nx6h                     1/1     Running     0          8d
```

- Check that the disk partition on the managed cluster is correct:

  a. Open a debug shell to the managed cluster:

```
$ oc debug node/sno-1.example.com
```

  b. Run **lsblk** to check the host disk partitions:

```
sh-4.4# lsblk
NAME   MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
sda      8:0    0 446.6G  0 disk
  |-sda1   8:1    0     1M  0 part
  |-sda2   8:2    0   127M  0 part
  |-sda3   8:3    0   384M  0 part /boot
  |-sda4   8:4    0 336.3G  0 part /sysroot
  `-sda5   8:5    0 100.1G  0 part /var/imageregistry (1)
sdb      8:16   0 446.6G  0 disk
sr0     11:0    1   104M  0 rom
```

(1) **/var/imageregistry** indicates that the disk is correctly partitioned.

Additional resources

- Accessing the registry

10.3. UPDATING MANAGED CLUSTERS IN A DISCONNECTED ENVIRONMENT WITH POLICYGENTEMPLATE RESOURCES AND TALM

You can use the Topology Aware Lifecycle Manager (TALM) to manage the software lifecycle of managed clusters that you have deployed by using GitOps Zero Touch Provisioning (ZTP) and Topology Aware Lifecycle Manager (TALM). TALM uses Red Hat Advanced Cluster Management (RHACM) PolicyGenTemplate policies to manage and control changes applied to target clusters.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching
- About the Topology Aware Lifecycle Manager

10.3.1. Setting up the disconnected environment

TALM can perform both platform and Operator updates.

You must mirror both the platform image and Operator images that you want to update to in your mirror registry before you can use TALM to update your disconnected clusters. Complete the following steps to mirror the images:

- For platform updates, you must perform the following steps:

  1. Mirror the desired OpenShift Container Platform image repository. Ensure that the desired platform image is mirrored by following the "Mirroring the OpenShift Container Platform image repository" procedure linked in the Additional Resources. Save the contents of the **imageContentSources** section in the **imageContentSources.yaml** file:

     Example output

     ```
     imageContentSources:
      - mirrors:
        - mirror-ocp-registry.ibmcloud.io.cpak:5000/openshift-release-dev/openshift4
        source: quay.io/openshift-release-dev/ocp-release
      - mirrors:
        - mirror-ocp-registry.ibmcloud.io.cpak:5000/openshift-release-dev/openshift4
        source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
     ```

  2. Save the image signature of the desired platform image that was mirrored. You must add the image signature to the **PolicyGenTemplate** CR for platform updates. To get the image signature, perform the following steps:

     a. Specify the desired OpenShift Container Platform tag by running the following command:

     ```
     $ OCP_RELEASE_NUMBER=<release_version>
     ```

     b. Specify the architecture of the cluster by running the following command:

     ```
     $ ARCHITECTURE=<cluster_architecture> 1
     ```

1 Specify the architecture of the cluster, such as **x86_64**, **aarch64**, **s390x**, or **ppc64le**.

c. Get the release image digest from Quay by running the following command

```
$ DIGEST="$(oc adm release info quay.io/openshift-release-dev/ocp-
release:${OCP_RELEASE_NUMBER}-${ARCHITECTURE} | sed -n 's/Pull From:
.*@//p')"
```

d. Set the digest algorithm by running the following command:

```
$ DIGEST_ALGO="${DIGEST%%:*}"
```

e. Set the digest signature by running the following command:

```
$ DIGEST_ENCODED="${DIGEST#*:}"
```

f. Get the image signature from the mirror.openshift.com website by running the following command:

```
$ SIGNATURE_BASE64=$(curl -s "https://mirror.openshift.com/pub/openshift-
v4/signatures/openshift/release/${DIGEST_ALGO}=${DIGEST_ENCODED}/signature
-1" | base64 -w0 && echo)
```

g. Save the image signature to the **checksum-<OCP_RELEASE_NUMBER>.yaml** file by running the following commands:

```
$ cat >checksum-${OCP_RELEASE_NUMBER}.yaml <<EOF
${DIGEST_ALGO}-${DIGEST_ENCODED}: ${SIGNATURE_BASE64}
EOF
```

3. Prepare the update graph. You have two options to prepare the update graph:

   a. Use the OpenShift Update Service.
   For more information about how to set up the graph on the hub cluster, see Deploy the operator for OpenShift Update Service and Build the graph data init container .

   b. Make a local copy of the upstream graph. Host the update graph on an **http** or **https** server in the disconnected environment that has access to the managed cluster. To download the update graph, use the following command:

```
$ curl -s https://api.openshift.com/api/upgrades_info/v1/graph?channel=stable-4.16 -
o ~/upgrade-graph_stable-4.16
```

- For Operator updates, you must perform the following task:
  - Mirror the Operator catalogs. Ensure that the desired operator images are mirrored by following the procedure in the "Mirroring Operator catalogs for use with disconnected clusters" section.

Additional resources

- Upgrading GitOps ZTP

- Mirroring the OpenShift Container Platform image repository
- Mirroring Operator catalogs for use with disconnected clusters
- Preparing the disconnected environment
- Understanding update channels and releases

10.3.2. Performing a platform update with PolicyGenTemplate CRs

You can perform a platform update with the TALM.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Mirror the desired image repository.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Create a **PolicyGenTemplate** CR for the platform update:
   a. Save the following **PolicyGenTemplate** CR in the **du-upgrade.yaml** file:

      Example of PolicyGenTemplate for platform update

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "du-upgrade"
  namespace: "ztp-group-du-sno"
spec:
  bindingRules:
    group-du-sno: ""
  mcp: "master"
  remediationAction: inform
  sourceFiles:
    - fileName: ImageSignature.yaml (1)
      policyName: "platform-upgrade-prep"
      binaryData:
        ${DIGEST_ALGO}-${DIGEST_ENCODED}: ${SIGNATURE_BASE64} (2)
    - fileName: DisconnectedICSP.yaml
      policyName: "platform-upgrade-prep"
      metadata:
        name: disconnected-internal-icsp-for-ocp
      spec:
        repositoryDigestMirrors: (3)
```

```
          - mirrors:
            - quay-intern.example.com/ocp4/openshift-release-dev
            source: quay.io/openshift-release-dev/ocp-release
          - mirrors:
            - quay-intern.example.com/ocp4/openshift-release-dev
            source: quay.io/openshift-release-dev/ocp-v4.0-art-dev
    - fileName: ClusterVersion.yaml 4
      policyName: "platform-upgrade"
      metadata:
        name: version
      spec:
        channel: "stable-4.16"
        upstream: http://upgrade.example.com/images/upgrade-graph_stable-4.16
        desiredUpdate:
          version: 4.16.4
      status:
        history:
          - version: 4.16.4
            state: "Completed"
```

1. The **ConfigMap** CR contains the signature of the desired release image to update to.
2. Shows the image signature of the desired OpenShift Container Platform release. Get the signature from the **checksum-${OCP_RELEASE_NUMBER}.yaml** file you saved when following the procedures in the "Setting up the environment" section.
3. Shows the mirror repository that contains the desired OpenShift Container Platform image. Get the mirrors from the **imageContentSources.yaml** file that you saved when following the procedures in the "Setting up the environment" section.
4. Shows the **ClusterVersion** CR to trigger the update. The **channel**, **upstream**, and **desiredVersion** fields are all required for image pre-caching.

The **PolicyGenTemplate** CR generates two policies:

- The **du-upgrade-platform-upgrade-prep** policy does the preparation work for the platform update. It creates the **ConfigMap** CR for the desired release image signature, creates the image content source of the mirrored release image repository, and updates the cluster version with the desired update channel and the update graph reachable by the managed cluster in the disconnected environment.
- The **du-upgrade-platform-upgrade** policy is used to perform platform upgrade.

b. Add the **du-upgrade.yaml** file contents to the **kustomization.yaml** file located in the GitOps ZTP Git repository for the **PolicyGenTemplate** CRs and push the changes to the Git repository.
ArgoCD pulls the changes from the Git repository and generates the policies on the hub cluster.

c. Check the created policies by running the following command:

```
$ oc get policies -A | grep platform-upgrade
```

2. Create the **ClusterGroupUpdate** CR for the platform update with the **spec.enable** field set to **false**.

a. Save the content of the platform update **ClusterGroupUpdate** CR with the **du-upgrade-platform-upgrade-prep** and the **du-upgrade-platform-upgrade** policies and the target clusters to the **cgu-platform-upgrade.yml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-platform-upgrade
  namespace: default
spec:
  managedPolicies:
  - du-upgrade-platform-upgrade-prep
  - du-upgrade-platform-upgrade
  preCaching: false
  clusters:
  - spoke1
  remediationStrategy:
    maxConcurrency: 1
  enable: false
```

b. Apply the **ClusterGroupUpdate** CR to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-upgrade.yml
```

3. Optional: Pre-cache the images for the platform update.

a. Enable pre-caching in the **ClusterGroupUpdate** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-platform-
upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

b. Monitor the update process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the hub cluster:

```
$ oc get cgu cgu-platform-upgrade -o jsonpath='{.status.precaching.status}'
```

4. Start the platform update:

a. Enable the **cgu-platform-upgrade** policy and disable pre-caching by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-platform-
upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

Additional resources

- Preparing the disconnected environment

10.3.3. Performing an Operator update with PolicyGenTemplate CRs

You can perform an Operator update with the TALM.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Mirror the desired index image, bundle images, and all Operator images referenced in the bundle images.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Update the **PolicyGenTemplate** CR for the Operator update.
   a. Update the **du-upgrade PolicyGenTemplate** CR with the following additional contents in the **du-upgrade.yaml** file:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "du-upgrade"
  namespace: "ztp-group-du-sno"
spec:
  bindingRules:
    group-du-sno: ""
  mcp: "master"
  remediationAction: inform
  sourceFiles:
    - fileName: DefaultCatsrc.yaml
      remediationAction: inform
      policyName: "operator-catsrc-policy"
      metadata:
        name: redhat-operators
      spec:
        displayName: Red Hat Operators Catalog
        image: registry.example.com:5000/olm/redhat-operators:v4.16 1
        updateStrategy: 2
          registryPoll:
            interval: 1h
      status:
        connectionState:
            lastObservedState: READY 3
```

1 The index image URL contains the desired Operator images. If the index images are always pushed to the same image name and tag, this change is not needed.

2. Set how frequently the Operator Lifecycle Manager (OLM) polls the index image for new Operator versions with the **registryPoll.interval** field. This change is not needed if a new index image tag is always pushed for y-stream and z-stream Operator updates. The **registryPoll.interval** field can be set to a shorter interval to expedite the update, however shorter intervals increase computational load. To counteract this behavior, you can restore **registryPoll.interval** to the default value once the update is complete.

3. Last observed state of the catalog connection. The **READY** value ensures that the **CatalogSource** policy is ready, indicating that the index pod is pulled and is running. This way, TALM upgrades the Operators based on up-to-date policy compliance states.

b. This update generates one policy, **du-upgrade-operator-catsrc-policy**, to update the **redhat-operators** catalog source with the new index images that contain the desired Operators images.

NOTE

If you want to use the image pre-caching for Operators and there are Operators from a different catalog source other than **redhat-operators**, you must perform the following tasks:

- Prepare a separate catalog source policy with the new index image or registry poll interval update for the different catalog source.

- Prepare a separate subscription policy for the desired Operators that are from the different catalog source.

For example, the desired SRIOV-FEC Operator is available in the **certified-operators** catalog source. To update the catalog source and the Operator subscription, add the following contents to generate two policies, **du-upgrade-fec-catsrc-policy** and **du-upgrade-subscriptions-fec-policy**:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "du-upgrade"
  namespace: "ztp-group-du-sno"
spec:
  bindingRules:
    group-du-sno: ""
  mcp: "master"
  remediationAction: inform
  sourceFiles:
      # ...
    - fileName: DefaultCatsrc.yaml
      remediationAction: inform
      policyName: "fec-catsrc-policy"
      metadata:
        name: certified-operators
      spec:
        displayName: Intel SRIOV-FEC Operator
        image: registry.example.com:5000/olm/far-edge-sriov-fec:v4.10
      updateStrategy:
        registryPoll:
          interval: 10m
  - fileName: AcceleratorsSubscription.yaml
    policyName: "subscriptions-fec-policy"
    spec:
      channel: "stable"
      source: certified-operators
```

c. Remove the specified subscriptions channels in the common **PolicyGenTemplate** CR, if they exist. The default subscriptions channels from the GitOps ZTP image are used for the update.

> **NOTE**
>
> The default channel for the Operators applied through GitOps ZTP 4.16 is **stable**, except for the **performance-addon-operator**. As of OpenShift Container Platform 4.11, the **performance-addon-operator** functionality was moved to the **node-tuning-operator**. For the 4.10 release, the default channel for PAO is **v4.10**. You can also specify the default channels in the common **PolicyGenTemplate** CR.

d. Push the **PolicyGenTemplate** CRs updates to the GitOps ZTP Git repository.
ArgoCD pulls the changes from the Git repository and generates the policies on the hub cluster.

e. Check the created policies by running the following command:

```
$ oc get policies -A | grep -E "catsrc-policy|subscription"
```

2. Apply the required catalog source updates before starting the Operator update.

a. Save the content of the **ClusterGroupUpgrade** CR named **operator-upgrade-prep** with the catalog source policies and the target managed clusters to the **cgu-operator-upgrade-prep.yml** file:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-operator-upgrade-prep
  namespace: default
spec:
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - du-upgrade-operator-catsrc-policy
  remediationStrategy:
    maxConcurrency: 1
```

b. Apply the policy to the hub cluster by running the following command:

```
$ oc apply -f cgu-operator-upgrade-prep.yml
```

c. Monitor the update process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies -A | grep -E "catsrc-policy"
```

3. Create the **ClusterGroupUpgrade** CR for the Operator update with the **spec.enable** field set to **false**.

a. Save the content of the Operator update **ClusterGroupUpgrade** CR with the **du-upgrade-operator-catsrc-policy** policy and the subscription policies created from the common **PolicyGenTemplate** and the target clusters to the **cgu-operator-upgrade.yml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-operator-upgrade
  namespace: default
spec:
  managedPolicies:
  - du-upgrade-operator-catsrc-policy (1)
  - common-subscriptions-policy (2)
  preCaching: false
  clusters:
  - spoke1
  remediationStrategy:
    maxConcurrency: 1
  enable: false
```

(1) The policy is needed by the image pre-caching feature to retrieve the operator images from the catalog source.

(2) The policy contains Operator subscriptions. If you have followed the structure and content of the reference **PolicyGenTemplates**, all Operator subscriptions are grouped into the **common-subscriptions-policy** policy.

NOTE

One **ClusterGroupUpgrade** CR can only pre-cache the images of the desired Operators defined in the subscription policy from one catalog source included in the **ClusterGroupUpgrade** CR. If the desired Operators are from different catalog sources, such as in the example of the SRIOV-FEC Operator, another **ClusterGroupUpgrade** CR must be created with **du-upgrade-fec-catsrc-policy** and **du-upgrade-subscriptions-fec-policy** policies for the SRIOV-FEC Operator images pre-caching and update.

b. Apply the **ClusterGroupUpgrade** CR to the hub cluster by running the following command:

```
$ oc apply -f cgu-operator-upgrade.yml
```

4. Optional: Pre-cache the images for the Operator update.

a. Before starting image pre-caching, verify the subscription policy is **NonCompliant** at this point by running the following command:

```
$ oc get policy common-subscriptions-policy -n <policy_namespace>
```

Example output

```
NAME                          REMEDIATION ACTION   COMPLIANCE STATE     AGE
common-subscriptions-policy   inform               NonCompliant         27d
```

b. Enable pre-caching in the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-operator-
upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

c. Monitor the process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the managed cluster:

```
$ oc get cgu cgu-operator-upgrade -o jsonpath='{.status.precaching.status}'
```

d. Check if the pre-caching is completed before starting the update by running the following command:

```
$ oc get cgu -n default cgu-operator-upgrade -ojsonpath='{.status.conditions}' | jq
```

Example output

```
[
    {
      "lastTransitionTime": "2022-03-08T20:49:08.000Z",
      "message": "The ClusterGroupUpgrade CR is not enabled",
      "reason": "UpgradeNotStarted",
      "status": "False",
      "type": "Ready"
    },
    {
      "lastTransitionTime": "2022-03-08T20:55:30.000Z",
      "message": "Precaching is completed",
      "reason": "PrecachingCompleted",
      "status": "True",
      "type": "PrecachingDone"
    }
]
```

5. Start the Operator update.

a. Enable the **cgu-operator-upgrade ClusterGroupUpgrade** CR and disable pre-caching to start the Operator update by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-operator-
upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

Additional resources

- Upgrading GitOps ZTP

10.3.4. Troubleshooting missed Operator updates with PolicyGenTemplate CRs

In some scenarios, Topology Aware Lifecycle Manager (TALM) might miss Operator updates due to an out-of-date policy compliance state.

After a catalog source update, it takes time for the Operator Lifecycle Manager (OLM) to update the subscription status. The status of the subscription policy might continue to show as compliant while TALM decides whether remediation is needed. As a result, the Operator specified in the subscription policy does not get upgraded.

To avoid this scenario, add another catalog source configuration to the **PolicyGenTemplate** and specify this configuration in the subscription for any Operators that require an update.

Procedure

1. Add a catalog source configuration in the **PolicyGenTemplate** resource:

```
- fileName: DefaultCatsrc.yaml
    remediationAction: inform
    policyName: "operator-catsrc-policy"
    metadata:
      name: redhat-operators
    spec:
      displayName: Red Hat Operators Catalog
      image: registry.example.com:5000/olm/redhat-operators:v{product-version}
      updateStrategy:
        registryPoll:
          interval: 1h
    status:
      connectionState:
          lastObservedState: READY
- fileName: DefaultCatsrc.yaml
    remediationAction: inform
    policyName: "operator-catsrc-policy"
    metadata:
      name: redhat-operators-v2 (1)
    spec:
      displayName: Red Hat Operators Catalog v2 (2)
      image: registry.example.com:5000/olredhat-operators:<version> (3)
      updateStrategy:
        registryPoll:
          interval: 1h
    status:
      connectionState:
          lastObservedState: READY
```

1 Update the name for the new configuration.

2 Update the display name for the new configuration.

3 Update the index image URL. This **fileName.spec.image** field overrides any configuration in the **DefaultCatsrc.yaml** file.

2. Update the **Subscription** resource to point to the new configuration for Operators that require an update:

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: operator-subscription
  namespace: operator-namspace
# ...
spec:
  source: redhat-operators-v2 1
# ...
```

1 Enter the name of the additional catalog source configuration that you defined in the **PolicyGenTemplate** resource.

10.3.5. Performing a platform and an Operator update together

You can perform a platform and an Operator update at the same time.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Update GitOps Zero Touch Provisioning (ZTP) to the latest version.
- Provision one or more managed clusters with GitOps ZTP.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Create the **PolicyGenTemplate** CR for the updates by following the steps described in the "Performing a platform update" and "Performing an Operator update" sections.

2. Apply the prep work for the platform and the Operator update.

   a. Save the content of the **ClusterGroupUpgrade** CR with the policies for platform update preparation work, catalog source updates, and target clusters to the **cgu-platform-operator-upgrade-prep.yml** file, for example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-platform-operator-upgrade-prep
  namespace: default
spec:
  managedPolicies:
  - du-upgrade-platform-upgrade-prep
  - du-upgrade-operator-catsrc-policy
  clusterSelector:
  - group-du-sno
  remediationStrategy:
    maxConcurrency: 10
  enable: true
```

b. Apply the **cgu-platform-operator-upgrade-prep.yml** file to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-operator-upgrade-prep.yml
```

c. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

3. Create the **ClusterGroupUpdate** CR for the platform and the Operator update with the **spec.enable** field set to **false**.

   a. Save the contents of the platform and Operator update **ClusterGroupUpdate** CR with the policies and the target clusters to the **cgu-platform-operator-upgrade.yml** file, as shown in the following example:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-du-upgrade
  namespace: default
spec:
  managedPolicies:
  - du-upgrade-platform-upgrade 1
  - du-upgrade-operator-catsrc-policy 2
  - common-subscriptions-policy 3
  preCaching: true
  clusterSelector:
  - group-du-sno
  remediationStrategy:
    maxConcurrency: 1
  enable: false
```

1 This is the platform update policy.

2 This is the policy containing the catalog source information for the Operators to be updated. It is needed for the pre-caching feature to determine which Operator images to download to the managed cluster.

3 This is the policy to update the Operators.

b. Apply the **cgu-platform-operator-upgrade.yml** file to the hub cluster by running the following command:

```
$ oc apply -f cgu-platform-operator-upgrade.yml
```

4. Optional: Pre-cache the images for the platform and the Operator update.

a. Enable pre-caching in the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-du-upgrade \
--patch '{"spec":{"preCaching": true}}' --type=merge
```

b. Monitor the update process and wait for the pre-caching to complete. Check the status of pre-caching by running the following command on the managed cluster:

```
$ oc get jobs,pods -n openshift-talm-pre-cache
```

c. Check if the pre-caching is completed before starting the update by running the following command:

```
$ oc get cgu cgu-du-upgrade -ojsonpath='{.status.conditions}'
```

5. Start the platform and Operator update.

a. Enable the **cgu-du-upgrade ClusterGroupUpgrade** CR to start the platform and the Operator update by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-du-upgrade \
--patch '{"spec":{"enable":true, "preCaching": false}}' --type=merge
```

b. Monitor the process. Upon completion, ensure that the policy is compliant by running the following command:

```
$ oc get policies --all-namespaces
```

NOTE

The CRs for the platform and Operator updates can be created from the beginning by configuring the setting to **spec.enable: true**. In this case, the update starts immediately after pre-caching completes and there is no need to manually enable the CR.

Both pre-caching and the update create extra resources, such as policies, placement bindings, placement rules, managed cluster actions, and managed cluster view, to help complete the procedures. Setting the **afterCompletion.deleteObjects** field to **true** deletes all these resources after the updates complete.

10.3.6. Removing Performance Addon Operator subscriptions from deployed clusters with PolicyGenTemplate CRs

In earlier versions of OpenShift Container Platform, the Performance Addon Operator provided automatic, low latency performance tuning for applications. In OpenShift Container Platform 4.11 or later, these functions are part of the Node Tuning Operator.

Do not install the Performance Addon Operator on clusters running OpenShift Container Platform 4.11 or later. If you upgrade to OpenShift Container Platform 4.11 or later, the Node Tuning Operator automatically removes the Performance Addon Operator.

NOTE

You need to remove any policies that create Performance Addon Operator subscriptions to prevent a re-installation of the Operator.

The reference DU profile includes the Performance Addon Operator in the **PolicyGenTemplate** CR **common-ranGen.yaml**. To remove the subscription from deployed managed clusters, you must update **common-ranGen.yaml**.

NOTE

If you install Performance Addon Operator 4.10.3-5 or later on OpenShift Container Platform 4.11 or later, the Performance Addon Operator detects the cluster version and automatically hibernates to avoid interfering with the Node Tuning Operator functions. However, to ensure best performance, remove the Performance Addon Operator from your OpenShift Container Platform 4.11 clusters.

Prerequisites

- Create a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for ArgoCD.
- Update to OpenShift Container Platform 4.11 or later.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Change the **complianceType** to **mustnothave** for the Performance Addon Operator namespace, Operator group, and subscription in the **common-ranGen.yaml** file.

```
- fileName: PaoSubscriptionNS.yaml
  policyName: "subscriptions-policy"
  complianceType: mustnothave
- fileName: PaoSubscriptionOperGroup.yaml
  policyName: "subscriptions-policy"
  complianceType: mustnothave
- fileName: PaoSubscription.yaml
  policyName: "subscriptions-policy"
  complianceType: mustnothave
```

2. Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The status of the **common-subscriptions-policy** policy changes to **Non-Compliant**.

3. Apply the change to your target clusters by using the Topology Aware Lifecycle Manager. For more information about rolling out configuration changes, see the "Additional resources" section.

4. Monitor the process. When the status of the **common-subscriptions-policy** policy for a target cluster is **Compliant**, the Performance Addon Operator has been removed from the cluster. Get the status of the **common-subscriptions-policy** by running the following command:

   ```
   $ oc get policy -n ztp-common common-subscriptions-policy
   ```

5. Delete the Performance Addon Operator namespace, Operator group and subscription CRs from **spec.sourceFiles** in the **common-ranGen.yaml** file.

6. Merge the changes with your custom site repository and wait for the ArgoCD application to synchronize the change to the hub cluster. The policy remains compliant.

10.3.7. Pre-caching user-specified images with TALM on single-node OpenShift clusters

You can pre-cache application-specific workload images on single-node OpenShift clusters before upgrading your applications.

You can specify the configuration options for the pre-caching jobs using the following custom resources (CR):

- **PreCachingConfig** CR
- **ClusterGroupUpgrade** CR

NOTE

All fields in the **PreCachingConfig** CR are optional.

Example PreCachingConfig CR

```
apiVersion: ran.openshift.io/v1alpha1
kind: PreCachingConfig
metadata:
  name: exampleconfig
  namespace: exampleconfig-ns
spec:
  overrides: 1
    platformImage: quay.io/openshift-release-dev/ocp-
release@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1ef
    operatorsIndexes:
      - registry.example.com:5000/custom-redhat-operators:1.0.0
    operatorsPackagesAndChannels:
      - local-storage-operator: stable
      - ptp-operator: stable
      - sriov-network-operator: stable
  spaceRequired: 30 Gi 2
  excludePrecachePatterns: 3
    - aws
    - vsphere
```

```
  additionalImages: 4
    -
quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925
ada29c559a47e2e1ef
    -
quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d3808fc925
ada29c559a47adfaef
    -
quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafdedga099
1234afdadfsa09
```

1. By default, TALM automatically populates the **platformImage**, **operatorsIndexes**, and the **operatorsPackagesAndChannels** fields from the policies of the managed clusters. You can specify values to override the default TALM-derived values for these fields.
2. Specifies the minimum required disk space on the cluster. If unspecified, TALM defines a default value for OpenShift Container Platform images. The disk space field must include an integer value and the storage unit. For example: **40 GiB**, **200 MB**, **1 TiB**.
3. Specifies the images to exclude from pre-caching based on image name matching.
4. Specifies the list of additional images to pre-cache.

Example ClusterGroupUpgrade CR with PreCachingConfig CR reference

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu
spec:
  preCaching: true 1
  preCachingConfigRef:
    name: exampleconfig 2
    namespace: exampleconfig-ns 3
```

1. The **preCaching** field set to **true** enables the pre-caching job.
2. The **preCachingConfigRef.name** field specifies the **PreCachingConfig** CR that you want to use.
3. The **preCachingConfigRef.namespace** specifies the namespace of the **PreCachingConfig** CR that you want to use.

10.3.7.1. Creating the custom resources for pre-caching

You must create the **PreCachingConfig** CR before or concurrently with the **ClusterGroupUpgrade** CR.

1. Create the **PreCachingConfig** CR with the list of additional images you want to pre-cache.

```
apiVersion: ran.openshift.io/v1alpha1
kind: PreCachingConfig
metadata:
  name: exampleconfig
  namespace: default (1)
spec:
[...]
  spaceRequired: 30Gi (2)
  additionalImages:
    -
quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d38
08fc925ada29c559a47e2e1ef
    -
quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d38
08fc925ada29c559a47adfaef
    -
quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafd
edga0991234afdadfsa09
```

1. The **namespace** must be accessible to the hub cluster.
2. It is recommended to set the minimum disk space required field to ensure that there is sufficient storage space for the pre-cached images.

2. Create a **ClusterGroupUpgrade** CR with the **preCaching** field set to **true** and specify the **PreCachingConfig** CR created in the previous step:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu
  namespace: default
spec:
  clusters:
  - sno1
  - sno2
  preCaching: true
  preCachingConfigRef:
  - name: exampleconfig
    namespace: default
  managedPolicies:
    - du-upgrade-platform-upgrade
    - du-upgrade-operator-catsrc-policy
    - common-subscriptions-policy
  remediationStrategy:
    timeout: 240
```

WARNING

Once you install the images on the cluster, you cannot change or delete them.

3. When you want to start pre-caching the images, apply the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f cgu.yaml
```

TALM verifies the **ClusterGroupUpgrade** CR.

From this point, you can continue with the TALM pre-caching workflow.

NOTE

All sites are pre-cached concurrently.

Verification

1. Check the pre-caching status on the hub cluster where the **ClusterUpgradeGroup** CR is applied by running the following command:

```
$ oc get cgu <cgu_name> -n <cgu_namespace> -oyaml
```

Example output

```
  precaching:
    spec:
      platformImage: quay.io/openshift-release-dev/ocp-
release@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d3808fc925ada29c559a47e2e1
ef
      operatorsIndexes:
        - registry.example.com:5000/custom-redhat-operators:1.0.0
      operatorsPackagesAndChannels:
        - local-storage-operator: stable
        - ptp-operator: stable
        - sriov-network-operator: stable
      excludePrecachePatterns:
        - aws
        - vsphere
      additionalImages:
        -
quay.io/exampleconfig/application1@sha256:3d5800990dee7cd4727d3fe238a97e2d2976d38
08fc925ada29c559a47e2e1ef
        -
quay.io/exampleconfig/application2@sha256:3d5800123dee7cd4727d3fe238a97e2d2976d38
08fc925ada29c559a47adfaef
        -
quay.io/exampleconfig/applicationN@sha256:4fe1334adfafadsf987123adfffdaf1243340adfafd
edga0991234afdadfsa09
      spaceRequired: "30"
    status:
      sno1: Starting
      sno2: Starting
```

The pre-caching configurations are validated by checking if the managed policies exist. Valid configurations of the **ClusterGroupUpgrade** and the **PreCachingConfig** CRs result in the following statuses:

Example output of valid CRs

```
- lastTransitionTime: "2023-01-01T00:00:01Z"
  message: All selected clusters are valid
  reason: ClusterSelectionCompleted
  status: "True"
  type: ClusterSelected
- lastTransitionTime: "2023-01-01T00:00:02Z"
  message: Completed validation
  reason: ValidationCompleted
  status: "True"
  type: Validated
- lastTransitionTime: "2023-01-01T00:00:03Z"
  message: Precaching spec is valid and consistent
  reason: PrecacheSpecIsWellFormed
  status: "True"
  type: PrecacheSpecValid
- lastTransitionTime: "2023-01-01T00:00:04Z"
  message: Precaching in progress for 1 clusters
  reason: InProgress
  status: "False"
  type: PrecachingSucceeded
```

Example of an invalid PreCachingConfig CR

```
Type:    "PrecacheSpecValid"
Status:  False,
Reason:  "PrecacheSpecIncomplete"
Message: "Precaching spec is incomplete: failed to get PreCachingConfig resource due to
PreCachingConfig.ran.openshift.io "<pre-caching_cr_name>" not found"
```

2. You can find the pre-caching job by running the following command on the managed cluster:

```
$ oc get jobs -n openshift-talo-pre-cache
```

Example of pre-caching job in progress

```
NAME        COMPLETIONS       DURATION      AGE
pre-cache   0/1               1s            1s
```

3. You can check the status of the pod created for the pre-caching job by running the following command:

```
$ oc describe pod pre-cache -n openshift-talo-pre-cache
```

Example of pre-caching job in progress

```
Type        Reason              Age     From              Message
Normal      SuccesfulCreate     19s     job-controller    Created pod: pre-cache-abcd1
```

4. You can get live updates on the status of the job by running the following command:

```
$ oc logs -f pre-cache-abcd1 -n openshift-talo-pre-cache
```

▪

5. To verify the pre-cache job is successfully completed, run the following command:

```
$ oc describe pod pre-cache -n openshift-talo-pre-cache
```

Example of completed pre-cache job

```
Type       Reason             Age    From              Message
Normal     SuccesfulCreate     5m19s  job-controller    Created pod: pre-cache-abcd1
Normal     Completed           19s    job-controller    Job completed
```

6. To verify that the images are successfully pre-cached on the single-node OpenShift, do the following:

   a. Enter into the node in debug mode:

   ```
   $ oc debug node/cnfdf00.example.lab
   ```

   b. Change root to **host**:

   ```
   $ chroot /host/
   ```

   c. Search for the desired images:

   ```
   $ sudo podman images | grep <operator_name>
   ```

Additional resources

- Using the container image precache feature

10.3.8. About the auto-created ClusterGroupUpgrade CR for GitOps ZTP

TALM has a controller called **ManagedClusterForCGU** that monitors the **Ready** state of the **ManagedCluster** CRs on the hub cluster and creates the **ClusterGroupUpgrade** CRs for GitOps Zero Touch Provisioning (ZTP).

For any managed cluster in the **Ready** state without a **ztp-done** label applied, the **ManagedClusterForCGU** controller automatically creates a **ClusterGroupUpgrade** CR in the **ztp-install** namespace with its associated RHACM policies that are created during the GitOps ZTP process. TALM then remediates the set of configuration policies that are listed in the auto-created **ClusterGroupUpgrade** CR to push the configuration CRs to the managed cluster.

If there are no policies for the managed cluster at the time when the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR with no policies is created. Upon completion of the **ClusterGroupUpgrade** the managed cluster is labeled as **ztp-done**. If there are policies that you want to apply for that managed cluster, manually create a **ClusterGroupUpgrade** as a day-2 operation.

Example of an auto-created ClusterGroupUpgrade CR for GitOps ZTP

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  generation: 1
```

```
  name: spoke1
  namespace: ztp-install
  ownerReferences:
  - apiVersion: cluster.open-cluster-management.io/v1
    blockOwnerDeletion: true
    controller: true
    kind: ManagedCluster
    name: spoke1
    uid: 98fdb9b2-51ee-4ee7-8f57-a84f7f35b9d5
  resourceVersion: "46666836"
  uid: b8be9cd2-764f-4a62-87d6-6b767852c7da
spec:
  actions:
    afterCompletion:
      addClusterLabels:
        ztp-done: "" 1
      deleteClusterLabels:
        ztp-running: ""
      deleteObjects: true
    beforeEnable:
      addClusterLabels:
        ztp-running: "" 2
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - common-spoke1-config-policy
  - common-spoke1-subscriptions-policy
  - group-spoke1-config-policy
  - spoke1-config-policy
  - group-spoke1-validator-du-policy
  preCaching: false
  remediationStrategy:
    maxConcurrency: 1
    timeout: 240
```

1 Applied to the managed cluster when TALM completes the cluster configuration.

2 Applied to the managed cluster when TALM starts deploying the configuration policies.

CHAPTER 11. USING HUB TEMPLATES IN POLICYGENERATOR OR POLICYGENTEMPLATE CRS

Topology Aware Lifecycle Manager supports partial Red Hat Advanced Cluster Management (RHACM) hub cluster template functions in configuration policies used with GitOps Zero Touch Provisioning (ZTP).

Hub-side cluster templates allow you to define configuration policies that can be dynamically customized to the target clusters. This reduces the need to create separate policies for many clusters with similiar configurations but with different values.

IMPORTANT

Policy templates are restricted to the same namespace as the namespace where the policy is defined. This means you must create the objects referenced in the hub template in the same namespace where the policy is created.

IMPORTANT

Using **PolicyGenTemplate** CRs to manage and deploy polices to managed clusters will be deprecated in an upcoming OpenShift Container Platform release. Equivalent and improved functionality is available using Red Hat Advanced Cluster Management (RHACM) and **PolicyGenerator** CRs.

For more information about **PolicyGenerator** resources, see the RHACM Policy Generator documentation.

Additional resources

- Configuring managed cluster policies by using PolicyGenerator resources
- Comparing RHACM PolicyGenerator and PolicyGenTemplate resource patching

11.1. USING RHACM HUB CLUSTER TEMPLATES IN CONFIGURATION POLICIES

Topology Aware Lifecycle Manager supports partial Red Hat Advanced Cluster Management (RHACM) hub cluster template functions in configuration policies used with GitOps Zero Touch Provisioning (ZTP).

The following supported hub template functions are available for use in GitOps ZTP with TALM:

- **fromConfigmap** returns the value of the provided data key in the named **ConfigMap** resource.

  NOTE

  There is a 1 MiB size limit for **ConfigMap** CRs. The effective size for **ConfigMap** CRs is further limited by the **last-applied-configuration** annotation. To avoid the **last-applied-configuration** limitation, add the following annotation to the template **ConfigMap**:

  ```
  argocd.argoproj.io/sync-options: Replace=true
  ```

- **base64enc** returns the base64-encoded value of the input string
- **base64dec** returns the decoded value of the base64-encoded input string
- **indent** returns the input string with added indent spaces
- **autoindent** returns the input string with added indent spaces based on the spacing used in the parent template
- **toInt** casts and returns the integer value of the input value
- **toBool** converts the input string into a boolean value, and returns the boolean

Various Open source community functions are also available for use with GitOps ZTP.

Additional resources

- RHACM support for hub cluster templates in configuration policies

11.2. EXAMPLE HUB TEMPLATES

The following code examples are valid hub templates. Each of these templates return values from the **ConfigMap** CR with the name **test-config** in the **default** namespace.

- Returns the value with the key **common-key**:

  ```
  {{hub fromConfigMap "default" "test-config" "common-key" hub}}
  ```

- Returns a string by using the concatenated value of the **.ManagedClusterName** field and the string **-name**:

  ```
  {{hub fromConfigMap "default" "test-config" (printf "%s-name" .ManagedClusterName) hub}}
  ```

- Casts and returns a boolean value from the concatenated value of the **.ManagedClusterName** field and the string **-name**:

  ```
  {{hub fromConfigMap "default" "test-config" (printf "%s-name" .ManagedClusterName) |
  toBool hub}}
  ```

- Casts and returns an integer value from the concatenated value of the **.ManagedClusterName** field and the string **-name**:

  ```
  {{hub (printf "%s-name" .ManagedClusterName) | fromConfigMap "default" "test-config" | toInt
  hub}}
  ```

11.3. SPECIFYING GROUP AND SITE CONFIGURATIONS IN GROUP POLICYGENERATOR OR POLICYGENTEMPLATE CRS

You can manage the configuration of fleets of clusters with **ConfigMap** CRs by using hub templates to populate the group and site values in the generated policies that get applied to the managed clusters. Using hub templates in site **PolicyGenerator** or **PolicyGentemplate** CRs means that you do not need to create a policy CR for each site.

You can group the clusters in a fleet in various categories, depending on the use case, for example hardware type or region. Each cluster should have a label corresponding to the group or groups that the cluster is in. If you manage the configuration values for each group in different **ConfigMap** CRs, then you require only one group policy CR to apply the changes to all the clusters in the group by using hub templates.

The following example shows you how to use three **ConfigMap** CRs and one **PolicyGenerator** CR to apply both site and group configuration to clusters grouped by hardware type and region.

NOTE

When you use the **fromConfigmap** function, the **printf** variable is only available for the template resource **data** key fields. You cannot use it with **name** and **namespace** fields.

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a Git repository where you manage your custom site configuration data. The repository must be accessible from the hub cluster and be defined as a source repository for the GitOps ZTP ArgoCD application.

Procedure

1. Create three **ConfigMap** CRs that contain the group and site configuration:

   a. Create a **ConfigMap** CR named **group-hardware-types-configmap** to hold the hardware-specific configuration. For example:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: group-hardware-types-configmap
  namespace: ztp-group
  annotations:
    argocd.argoproj.io/sync-options: Replace=true 1
data:
  # SriovNetworkNodePolicy.yaml
  hardware-type-1-sriov-node-policy-pfNames-1: "[\"ens5f0\"]"
  hardware-type-1-sriov-node-policy-pfNames-2: "[\"ens7f0\"]"
  # PerformanceProfile.yaml
  hardware-type-1-cpu-isolated: "2-31,34-63"
  hardware-type-1-cpu-reserved: "0-1,32-33"
  hardware-type-1-hugepages-default: "1G"
  hardware-type-1-hugepages-size: "1G"
  hardware-type-1-hugepages-count: "32"
```

1 The **argocd.argoproj.io/sync-options** annotation is required only if the **ConfigMap** is larger than 1 MiB in size.

   b. Create a **ConfigMap** CR named **group-zones-configmap** to hold the regional configuration. For example:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: group-zones-configmap
  namespace: ztp-group
data:
  # ClusterLogForwarder.yaml
  zone-1-cluster-log-fwd-outputs: "[{\"type\":\"kafka\", \"name\":\"kafka-open\",
\"url\":\"tcp://10.46.55.190:9092/test\"}]"
  zone-1-cluster-log-fwd-pipelines: "[{\"inputRefs\":[\"audit\", \"infrastructure\"], \"labels\":
{\"label1\": \"test1\", \"label2\": \"test2\", \"label3\": \"test3\", \"label4\": \"test4\"}, \"name\":
\"all-to-default\", \"outputRefs\": [\"kafka-open\"]}]"
```

c. Create a **ConfigMap** CR named **site-data-configmap** to hold the site-specific configuration. For example:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: site-data-configmap
  namespace: ztp-group
data:
  # SriovNetwork.yaml
  du-sno-1-zone-1-sriov-network-vlan-1: "140"
  du-sno-1-zone-1-sriov-network-vlan-2: "150"
```

NOTE

Each **ConfigMap** CR must be in the same namespace as the policy to be generated from the group **PolicyGenerator** CR.

2. Commit the **ConfigMap** CRs in Git, and then push to the Git repository being monitored by the Argo CD application.

3. Apply the hardware type and region labels to the clusters. The following command applies to a single cluster named **du-sno-1-zone-1** and the labels chosen are **"hardware-type": "hardware-type-1"** and **"group-du-sno-zone": "zone-1"**:

```
$ oc patch managedclusters.cluster.open-cluster-management.io/du-sno-1-zone-1 --type
merge -p '{"metadata":{"labels":{"hardware-type": "hardware-type-1", "group-du-sno-zone":
"zone-1"}}}'
```

4. Depending on your requirements, Create a group **PolicyGenerator** or **PolicyGentemplate** CR that uses hub templates to obtain the required data from the **ConfigMap** objects:

   a. Create a group **PolicyGenerator** CR. This example **PolicyGenerator** CR configures logging, VLAN IDs, NICs and Performance Profile for the clusters that match the labels listed the under **policyDefaults.placement** field:

```
---
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
    name: group-du-sno-pgt
```

```yaml
placementBindingDefaults:
  name: group-du-sno-pgt-placement-binding
policyDefaults:
  placement:
    labelSelector:
      matchExpressions:
        - key: group-du-sno-zone
          operator: In
          values:
            - zone-1
        - key: hardware-type
          operator: In
          values:
            - hardware-type-1
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: group-du-sno-pgt-group-du-sno-cfg-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "10"
    manifests:
      - path: source-crs/ClusterLogForwarder.yaml
        patches:
          - spec:
              outputs: '{{hub fromConfigMap "" "group-zones-configmap" (printf "%s-cluster-log-fwd-outputs" (index .ManagedClusterLabels "group-du-sno-zone")) | toLiteral hub}}'
              pipelines: '{{hub fromConfigMap "" "group-zones-configmap" (printf "%s-cluster-log-fwd-pipelines" (index .ManagedClusterLabels "group-du-sno-zone")) | toLiteral hub}}'
      - path: source-crs/PerformanceProfile-MCP-master.yaml
        patches:
          - metadata:
              name: openshift-node-performance-profile
            spec:
              additionalKernelArgs:
                - rcupdate.rcu_normal_after_boot=0
                - vfio_pci.enable_sriov=1
                - vfio_pci.disable_idle_d3=1
                - efi=runtime
              cpu:
                isolated: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-cpu-isolated" (index .ManagedClusterLabels "hardware-type")) hub}}'
                reserved: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-cpu-reserved" (index .ManagedClusterLabels "hardware-type")) hub}}'
              hugepages:
                defaultHugepagesSize: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-hugepages-default" (index .ManagedClusterLabels "hardware-type")) hub}}'
```

```
                    pages:
                        - count: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf
"%s-hugepages-count" (index .ManagedClusterLabels "hardware-type")) | toInt hub}}'
                          size: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf
"%s-hugepages-size" (index .ManagedClusterLabels "hardware-type")) hub}}'
                realTimeKernel:
                    enabled: true
    - name: group-du-sno-pgt-group-du-sno-sriov-policy
      policyAnnotations:
        ran.openshift.io/ztp-deploy-wave: "100"
      manifests:
        - path: source-crs/SriovNetwork.yaml
          patches:
            - metadata:
                name: sriov-nw-du-fh
              spec:
                resourceName: du_fh
                vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-
vlan-1" .ManagedClusterName) | toInt hub}}'
        - path: source-crs/SriovNetworkNodePolicy-MCP-master.yaml
          patches:
            - metadata:
                name: sriov-nnp-du-fh
              spec:
                deviceType: netdevice
                isRdma: false
                nicSelector:
                    pfNames: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf
"%s-sriov-node-policy-pfNames-1" (index .ManagedClusterLabels "hardware-type")) |
toLiteral hub}}'
                numVfs: 8
                priority: 10
                resourceName: du_fh
        - path: source-crs/SriovNetwork.yaml
          patches:
            - metadata:
                name: sriov-nw-du-mh
              spec:
                resourceName: du_mh
                vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-
vlan-2" .ManagedClusterName) | toInt hub}}'
        - path: source-crs/SriovNetworkNodePolicy-MCP-master.yaml
          patches:
            - metadata:
                name: sriov-nw-du-fh
              spec:
                deviceType: netdevice
                isRdma: false
                nicSelector:
                    pfNames: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf
"%s-sriov-node-policy-pfNames-2" (index .ManagedClusterLabels "hardware-type")) |
toLiteral hub}}'
                numVfs: 8
                priority: 10
                resourceName: du_fh
```

b. Create a group **PolicyGenTemplate** CR. This example **PolicyGenTemplate** CR configures logging, VLAN IDs, NICs and Performance Profile for the clusters that match the labels listed under **spec.bindingRules**:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: group-du-sno-pgt
  namespace: ztp-group
spec:
  bindingRules:
    # These policies will correspond to all clusters with these labels
    group-du-sno-zone: "zone-1"
    hardware-type: "hardware-type-1"
  mcp: "master"
  sourceFiles:
    - fileName: ClusterLogForwarder.yaml # wave 10
      policyName: "group-du-sno-cfg-policy"
      spec:
        outputs: '{{hub fromConfigMap "" "group-zones-configmap" (printf "%s-cluster-log-
fwd-outputs" (index .ManagedClusterLabels "group-du-sno-zone")) | toLiteral hub}}'
        pipelines: '{{hub fromConfigMap "" "group-zones-configmap" (printf "%s-cluster-log-
fwd-pipelines" (index .ManagedClusterLabels "group-du-sno-zone")) | toLiteral hub}}'

    - fileName: PerformanceProfile.yaml # wave 10
      policyName: "group-du-sno-cfg-policy"
      metadata:
        name: openshift-node-performance-profile
      spec:
        additionalKernelArgs:
        - rcupdate.rcu_normal_after_boot=0
        - vfio_pci.enable_sriov=1
        - vfio_pci.disable_idle_d3=1
        - efi=runtime
        cpu:
          isolated: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-
cpu-isolated" (index .ManagedClusterLabels "hardware-type")) hub}}'
          reserved: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-
cpu-reserved" (index .ManagedClusterLabels "hardware-type")) hub}}'
        hugepages:
          defaultHugepagesSize: '{{hub fromConfigMap "" "group-hardware-types-
configmap" (printf "%s-hugepages-default" (index .ManagedClusterLabels "hardware-
type")) hub}}'
          pages:
            - size: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-
hugepages-size" (index .ManagedClusterLabels "hardware-type")) hub}}'
              count: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-
hugepages-count" (index .ManagedClusterLabels "hardware-type")) | toInt hub}}'
        realTimeKernel:
          enabled: true

    - fileName: SriovNetwork.yaml # wave 100
      policyName: "group-du-sno-sriov-policy"
      metadata:
        name: sriov-nw-du-fh
      spec:
        resourceName: du_fh
        vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-vlan-1" .ManagedClusterName) | toInt hub}}'

    - fileName: SriovNetworkNodePolicy.yaml # wave 100
      policyName: "group-du-sno-sriov-policy"
      metadata:
        name: sriov-nnp-du-fh
      spec:
        deviceType: netdevice
        isRdma: false
        nicSelector:
          pfNames: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-sriov-node-policy-pfNames-1" (index .ManagedClusterLabels "hardware-type")) | toLiteral hub}}'
        numVfs: 8
        priority: 10
        resourceName: du_fh

    - fileName: SriovNetwork.yaml # wave 100
      policyName: "group-du-sno-sriov-policy"
      metadata:
        name: sriov-nw-du-mh
      spec:
        resourceName: du_mh
        vlan: '{{hub fromConfigMap "" "site-data-configmap" (printf "%s-sriov-network-vlan-2" .ManagedClusterName) | toInt hub}}'

    - fileName: SriovNetworkNodePolicy.yaml # wave 100
      policyName: "group-du-sno-sriov-policy"
      metadata:
        name: sriov-nw-du-fh
      spec:
        deviceType: netdevice
        isRdma: false
        nicSelector:
          pfNames: '{{hub fromConfigMap "" "group-hardware-types-configmap" (printf "%s-sriov-node-policy-pfNames-2" (index .ManagedClusterLabels "hardware-type")) | toLiteral hub}}'
        numVfs: 8
        priority: 10
        resourceName: du_fh
```

NOTE

To retrieve site-specific configuration values, use the **.ManagedClusterName** field. This is a template context value set to the name of the target managed cluster.

To retrieve group-specific configuration, use the **.ManagedClusterLabels** field. This is a template context value set to the value of the managed cluster's labels.

5. Commit the site **PolicyGenerator** or **PolicyGentemplate** CR in Git and push to the Git repository that is monitored by the ArgoCD application.

NOTE

Subsequent changes to the referenced **ConfigMap** CR are not automatically synced to the applied policies. You need to manually sync the new **ConfigMap** changes to update existing **PolicyGenerator** CRs. See "Syncing new ConfigMap changes to existing PolicyGenerator or PolicyGenTemplate CRs".

You can use the same **PolicyGenerator** or **PolicyGentemplate** CR for multiple clusters. If there is a configuration change, then the only modifications you need to make are to the **ConfigMap** objects that hold the configuration for each cluster and the labels of the managed clusters.

11.4. SYNCING NEW CONFIGMAP CHANGES TO EXISTING POLICYGENERATOR OR POLICYGENTEMPLATE CRS

Prerequisites

- You have installed the OpenShift CLI (**oc**).
- You have logged in to the hub cluster as a user with **cluster-admin** privileges.
- You have created a **PolicyGenerator** or **PolicyGentemplate** CR that pulls information from a **ConfigMap** CR using hub cluster templates.

Procedure

1. Update the contents of your **ConfigMap** CR, and apply the changes in the hub cluster.
2. To sync the contents of the updated **ConfigMap** CR to the deployed policy, do either of the following:
   a. Option 1: Delete the existing policy. ArgoCD uses the **PolicyGenerator** or **PolicyGentemplate** CR to immediately recreate the deleted policy. For example, run the following command:

      ```
      $ oc delete policy <policy_name> -n <policy_namespace>
      ```

   b. Option 2: Apply a special annotation **policy.open-cluster-management.io/trigger-update** to the policy with a different value every time when you update the **ConfigMap**. For example:

      ```
      $ oc annotate policy <policy_name> -n <policy_namespace> policy.open-cluster-
      management.io/trigger-update="1"
      ```

      NOTE

      You must apply the updated policy for the changes to take effect. For more information, see Special annotation for reprocessing.

3. Optional: If it exists, delete the **ClusterGroupUpdate** CR that contains the policy. For example:

   ```
   $ oc delete clustergroupupgrade <cgu_name> -n <cgu_namespace>
   ```

a. Create a new **ClusterGroupUpdate** CR that includes the policy to apply with the updated **ConfigMap** changes. For example, add the following YAML to the file **cgr-example.yaml**:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: <cgr_name>
  namespace: <policy_namespace>
spec:
  managedPolicies:
    - <managed_policy>
  enable: true
  clusters:
  - <managed_cluster_1>
  - <managed_cluster_2>
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
```

b. Apply the updated policy:

```
$ oc apply -f cgr-example.yaml
```

CHAPTER 12. UPDATING MANAGED CLUSTERS WITH THE TOPOLOGY AWARE LIFECYCLE MANAGER

You can use the Topology Aware Lifecycle Manager (TALM) to manage the software lifecycle of multiple clusters. TALM uses Red Hat Advanced Cluster Management (RHACM) policies to perform changes on the target clusters.

IMPORTANT

Using PolicyGenerator resources with GitOps ZTP is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

12.1. ABOUT THE TOPOLOGY AWARE LIFECYCLE MANAGER CONFIGURATION

The Topology Aware Lifecycle Manager (TALM) manages the deployment of Red Hat Advanced Cluster Management (RHACM) policies for one or more OpenShift Container Platform clusters. Using TALM in a large network of clusters allows the phased rollout of policies to the clusters in limited batches. This helps to minimize possible service disruptions when updating. With TALM, you can control the following actions:

- The timing of the update
- The number of RHACM-managed clusters
- The subset of managed clusters to apply the policies to
- The update order of the clusters
- The set of policies remediated to the cluster
- The order of policies remediated to the cluster
- The assignment of a canary cluster

For single-node OpenShift, the Topology Aware Lifecycle Manager (TALM) offers the following features:

- Create a backup of a deployment before an upgrade
- Pre-caching images for clusters with limited bandwidth

TALM supports the orchestration of the OpenShift Container Platform y-stream and z-stream updates, and day-two operations on y-streams and z-streams.

12.2. ABOUT MANAGED POLICIES USED WITH TOPOLOGY AWARE LIFECYCLE MANAGER

The Topology Aware Lifecycle Manager (TALM) uses RHACM policies for cluster updates.

TALM can be used to manage the rollout of any policy CR where the **remediationAction** field is set to **inform**. Supported use cases include the following:

- Manual user creation of policy CRs
- Automatically generated policies from the **PolicyGenerator** or **PolicyGentemplate** custom resource definition (CRD)

For policies that update an Operator subscription with manual approval, TALM provides additional functionality that approves the installation of the updated Operator.

For more information about managed policies, see Policy Overview in the RHACM documentation.

Additional resources

- About the PolicyGenerator CRD

12.3. INSTALLING THE TOPOLOGY AWARE LIFECYCLE MANAGER BY USING THE WEB CONSOLE

You can use the OpenShift Container Platform web console to install the Topology Aware Lifecycle Manager.

Prerequisites

- Install the latest version of the RHACM Operator.
- TALM 4.16 requires RHACM 2.9 or later.
- Set up a hub cluster with a disconnected registry.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. In the OpenShift Container Platform web console, navigate to **Operators → OperatorHub**.
2. Search for the **Topology Aware Lifecycle Manager** from the list of available Operators, and then click **Install**.
3. Keep the default selection of **Installation mode** ["All namespaces on the cluster (default)"] and **Installed Namespace** ("openshift-operators") to ensure that the Operator is installed properly.
4. Click **Install**.

Verification

To confirm that the installation is successful:

1. Navigate to the **Operators → Installed Operators** page.
2. Check that the Operator is installed in the **All Namespaces** namespace and its status is **Succeeded**.

If the Operator is not installed successfully:

1. Navigate to the **Operators** → **Installed Operators** page and inspect the **Status** column for any errors or failures.

2. Navigate to the **Workloads** → **Pods** page and check the logs in any containers in the **cluster-group-upgrades-controller-manager** pod that are reporting issues.

12.4. INSTALLING THE TOPOLOGY AWARE LIFECYCLE MANAGER BY USING THE CLI

You can use the OpenShift CLI (**oc**) to install the Topology Aware Lifecycle Manager (TALM).

Prerequisites

- Install the OpenShift CLI (**oc**).
- Install the latest version of the RHACM Operator.
- TALM 4.16 requires RHACM 2.9 or later.
- Set up a hub cluster with disconnected registry.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Create a **Subscription** CR:

   a. Define the **Subscription** CR and save the YAML file, for example, **talm-subscription.yaml**:

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: openshift-topology-aware-lifecycle-manager-subscription
  namespace: openshift-operators
spec:
  channel: "stable"
  name: topology-aware-lifecycle-manager
  source: redhat-operators
  sourceNamespace: openshift-marketplace
```

   b. Create the **Subscription** CR by running the following command:

```
$ oc create -f talm-subscription.yaml
```

Verification

1. Verify that the installation succeeded by inspecting the CSV resource:

```
$ oc get csv -n openshift-operators
```

Example output

```
NAME                                    DISPLAY                      VERSION
REPLACES                     PHASE
topology-aware-lifecycle-manager.4.16.x   Topology Aware Lifecycle Manager   4.16.x
Succeeded
```

2. Verify that the TALM is up and running:

```
$ oc get deploy -n openshift-operators
```

Example output

```
NAMESPACE                              NAME                                    READY   UP-TO-
DATE   AVAILABLE   AGE
openshift-operators                    cluster-group-upgrades-controller-manager       1/1
1          1          14s
```

12.5. ABOUT THE CLUSTERGROUPUPGRADE CR

The Topology Aware Lifecycle Manager (TALM) builds the remediation plan from the **ClusterGroupUpgrade** CR for a group of clusters. You can define the following specifications in a **ClusterGroupUpgrade** CR:

- Clusters in the group
- Blocking **ClusterGroupUpgrade** CRs
- Applicable list of managed policies
- Number of concurrent updates
- Applicable canary updates
- Actions to perform before and after the update
- Update timing

You can control the start time of an update using the **enable** field in the **ClusterGroupUpgrade** CR. For example, if you have a scheduled maintenance window of four hours, you can prepare a **ClusterGroupUpgrade** CR with the **enable** field set to **false**.

You can set the timeout by configuring the **spec.remediationStrategy.timeout** setting as follows:

```
spec
  remediationStrategy:
          maxConcurrency: 1
          timeout: 240
```

You can use the **batchTimeoutAction** to determine what happens if an update fails for a cluster. You can specify **continue** to skip the failing cluster and continue to upgrade other clusters, or **abort** to stop policy remediation for all clusters. Once the timeout elapses, TALM removes all **enforce** policies to ensure that no further updates are made to clusters.

To apply the changes, you set the **enabled** field to **true**.

For more information see the "Applying update policies to managed clusters" section.

As TALM works through remediation of the policies to the specified clusters, the **ClusterGroupUpgrade** CR can report true or false statuses for a number of conditions.

NOTE

After TALM completes a cluster update, the cluster does not update again under the control of the same **ClusterGroupUpgrade** CR. You must create a new **ClusterGroupUpgrade** CR in the following cases:

- When you need to update the cluster again
- When the cluster changes to non-compliant with the **inform** policy after being updated

12.5.1. Selecting clusters

TALM builds a remediation plan and selects clusters based on the following fields:

- The **clusterLabelSelector** field specifies the labels of the clusters that you want to update. This consists of a list of the standard label selectors from **k8s.io/apimachinery/pkg/apis/meta/v1**. Each selector in the list uses either label value pairs or label expressions. Matches from each selector are added to the final list of clusters along with the matches from the **clusterSelector** field and the **cluster** field.
- The **clusters** field specifies a list of clusters to update.
- The **canaries** field specifies the clusters for canary updates.
- The **maxConcurrency** field specifies the number of clusters to update in a batch.
- The **actions** field specifies **beforeEnable** actions that TALM takes as it begins the update process, and **afterCompletion** actions that TALM takes as it completes policy remediation for each cluster.

You can use the **clusters**, **clusterLabelSelector**, and **clusterSelector** fields together to create a combined list of clusters.

The remediation plan starts with the clusters listed in the **canaries** field. Each canary cluster forms a single-cluster batch.

Sample ClusterGroupUpgrade CR with the enabled field set to false

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  creationTimestamp: '2022-11-18T16:27:15Z'
  finalizers:
    - ran.openshift.io/cleanup-finalizer
  generation: 1
  name: talm-cgu
  namespace: talm-namespace
  resourceVersion: '40451823'
  uid: cca245a5-4bca-45fa-89c0-aa6af81a596c
Spec:
  actions:
    afterCompletion: (1)
    addClusterLabels:
     upgrade-done: ""
    deleteClusterLabels:
     upgrade-running: ""
    deleteObjects: true
   beforeEnable: 2
    addClusterLabels:
     upgrade-running: ""
  backup: false
  clusters: 3
   - spoke1
  enable: false 4
  managedPolicies: 5
   - talm-policy
  preCaching: false
  remediationStrategy: 6
   canaries: 7
     - spoke1
   maxConcurrency: 2 8
   timeout: 240
  clusterLabelSelectors: 9
   - matchExpressions:
    - key: label1
    operator: In
    values:
     - value1a
     - value1b
  batchTimeoutAction: 10
 status: 11
   computedMaxConcurrency: 2
   conditions:
    - lastTransitionTime: '2022-11-18T16:27:15Z'
     message: All selected clusters are valid
     reason: ClusterSelectionCompleted
     status: 'True'
     type: ClustersSelected 12
    - lastTransitionTime: '2022-11-18T16:27:15Z'
     message: Completed validation
     reason: ValidationCompleted
     status: 'True'
     type: Validated 13
    - lastTransitionTime: '2022-11-18T16:37:16Z'
     message: Not enabled
     reason: NotEnabled
     status: 'False'
     type: Progressing
   managedPoliciesForUpgrade:
    - name: talm-policy
     namespace: talm-namespace
   managedPoliciesNs:
    talm-policy: talm-namespace
   remediationPlan:
    - - spoke1
    - - spoke2
      - spoke3
  status:
```

1. Specifies the action that TALM takes when it completes policy remediation for each cluster.
2. Specifies the action that TALM takes as it begins the update process.
3. Defines the list of clusters to update.
4. The **enable** field is set to **false**.
5. Lists the user-defined set of policies to remediate.
6. Defines the specifics of the cluster updates.
7. Defines the clusters for canary updates.
8. Defines the maximum number of concurrent updates in a batch. The number of remediation batches is the number of canary clusters, plus the number of clusters, except the canary clusters, divided by the **maxConcurrency** value. The clusters that are already compliant with all the managed policies are excluded from the remediation plan.
9. Displays the parameters for selecting clusters.
10. Controls what happens if a batch times out. Possible values are **abort** or **continue**. If unspecified, the default is **continue**.
11. Displays information about the status of the updates.
12. The **ClustersSelected** condition shows that all selected clusters are valid.
13. The **Validated** condition shows that all selected clusters have been validated.

NOTE

Any failures during the update of a canary cluster stops the update process.

When the remediation plan is successfully created, you can you set the **enable** field to **true** and TALM starts to update the non-compliant clusters with the specified managed policies.

NOTE

You can only make changes to the **spec** fields if the **enable** field of the **ClusterGroupUpgrade** CR is set to **false**.

12.5.2. Validating

TALM checks that all specified managed policies are available and correct, and uses the **Validated** condition to report the status and reasons as follows:

- **true**
  Validation is completed.

- **false**
  Policies are missing or invalid, or an invalid platform image has been specified.

12.5.3. Pre-caching

Clusters might have limited bandwidth to access the container image registry, which can cause a timeout before the updates are completed. On single-node OpenShift clusters, you can use pre-caching to avoid this. The container image pre-caching starts when you create a **ClusterGroupUpgrade** CR with the **preCaching** field set to **true**. TALM compares the available disk space with the estimated OpenShift Container Platform image size to ensure that there is enough space. If a cluster has insufficient space, TALM cancels pre-caching for that cluster and does not remediate policies on it.

TALM uses the **PrecacheSpecValid** condition to report status information as follows:

- **true**
  The pre-caching spec is valid and consistent.

- **false**
  The pre-caching spec is incomplete.

TALM uses the **PrecachingSucceeded** condition to report status information as follows:

- **true**
  TALM has concluded the pre-caching process. If pre-caching fails for any cluster, the update fails for that cluster but proceeds for all other clusters. A message informs you if pre-caching has failed for any clusters.

- **false**
  Pre-caching is still in progress for one or more clusters or has failed for all clusters.

For more information see the "Using the container image pre-cache feature" section.

12.5.4. Creating a backup

For single-node OpenShift, TALM can create a backup of a deployment before an update. If the update fails, you can recover the previous version and restore a cluster to a working state without requiring a reprovision of applications. To use the backup feature you first create a **ClusterGroupUpgrade** CR with the **backup** field set to **true**. To ensure that the contents of the backup are up to date, the backup is not taken until you set the **enable** field in the **ClusterGroupUpgrade** CR to **true**.

TALM uses the **BackupSucceeded** condition to report the status and reasons as follows:

- **true**
  Backup is completed for all clusters or the backup run has completed but failed for one or more clusters. If backup fails for any cluster, the update fails for that cluster but proceeds for all other clusters.

- **false**
  Backup is still in progress for one or more clusters or has failed for all clusters.

For more information, see the "Creating a backup of cluster resources before upgrade" section.

12.5.5. Updating clusters

TALM enforces the policies following the remediation plan. Enforcing the policies for subsequent batches starts immediately after all the clusters of the current batch are compliant with all the managed policies. If the batch times out, TALM moves on to the next batch. The timeout value of a batch is the **spec.timeout** field divided by the number of batches in the remediation plan.

TALM uses the **Progressing** condition to report the status and reasons as follows:

- **true**
  TALM is remediating non-compliant policies.
- **false**
  The update is not in progress. Possible reasons for this are:
  - All clusters are compliant with all the managed policies.
  - The update has timed out as policy remediation took too long.
  - Blocking CRs are missing from the system or have not yet completed.
  - The **ClusterGroupUpgrade** CR is not enabled.
  - Backup is still in progress.

NOTE

The managed policies apply in the order that they are listed in the **managedPolicies** field in the **ClusterGroupUpgrade** CR. One managed policy is applied to the specified clusters at a time. When a cluster complies with the current policy, the next managed policy is applied to it.

Sample ClusterGroupUpgrade CR in the Progressing state

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  creationTimestamp: '2022-11-18T16:27:15Z'
  finalizers:
    - ran.openshift.io/cleanup-finalizer
  generation: 1
  name: talm-cgu
  namespace: talm-namespace
  resourceVersion: '40451823'
  uid: cca245a5-4bca-45fa-89c0-aa6af81a596c
Spec:
  actions:
    afterCompletion:
      deleteObjects: true
    beforeEnable: {}
  backup: false
  clusters:
    - spoke1
  enable: true
  managedPolicies:
    - talm-policy
  preCaching: true
  remediationStrategy:
    canaries:
      - spoke1
    maxConcurrency: 2
    timeout: 240
  clusterLabelSelectors:
    - matchExpressions:
      - key: label1
      operator: In
      values:
        - value1a
        - value1b
  batchTimeoutAction:
status:
    clusters:
      - name: spoke1
        state: complete
    computedMaxConcurrency: 2
    conditions:
      - lastTransitionTime: '2022-11-18T16:27:15Z'
        message: All selected clusters are valid
        reason: ClusterSelectionCompleted
        status: 'True'
        type: ClustersSelected
      - lastTransitionTime: '2022-11-18T16:27:15Z'
        message: Completed validation
        reason: ValidationCompleted
        status: 'True'
        type: Validated
      - lastTransitionTime: '2022-11-18T16:37:16Z'
        message: Remediating non-compliant policies
        reason: InProgress
        status: 'True'
        type: Progressing [1]
    managedPoliciesForUpgrade:
      - name: talm-policy
        namespace: talm-namespace
    managedPoliciesNs:
      talm-policy: talm-namespace
    remediationPlan:
      - - spoke1
      - - spoke2
        - spoke3
    status:
      currentBatch: 2
      currentBatchRemediationProgress:
        spoke2:
          state: Completed
        spoke3:
          policyIndex: 0
          state: InProgress
      currentBatchStartedAt: '2022-11-18T16:27:16Z'
      startedAt: '2022-11-18T16:27:15Z'
```

[1] The **Progressing** fields show that TALM is in the process of remediating policies.

12.5.6. Update status

TALM uses the **Succeeded** condition to report the status and reasons as follows:

- **true**
  All clusters are compliant with the specified managed policies.
- **false**
  Policy remediation failed as there were no clusters available for remediation, or because policy remediation took too long for one of the following reasons:
  - The current batch contains canary updates and the cluster in the batch does not comply with all the managed policies within the batch timeout.
  - Clusters did not comply with the managed policies within the **timeout** value specified in the **remediationStrategy** field.

Sample **ClusterGroupUpgrade** CR in the **Succeeded** state

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-upgrade-complete
  namespace: default
spec:
  clusters:
  - spoke1
  - spoke4
  enable: true
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  remediationStrategy:
    maxConcurrency: 1
    timeout: 240
status: (1)
  clusters:
    - name: spoke1
      state: complete
    - name: spoke4
      state: complete
  conditions:
  - message: All selected clusters are valid
    reason: ClusterSelectionCompleted
    status: "True"
    type: ClustersSelected
  - message: Completed validation
    reason: ValidationCompleted
    status: "True"
    type: Validated
  - message: All clusters are compliant with all the managed policies
    reason: Completed
    status: "False"
    type: Progressing (2)
  - message: All clusters are compliant with all the managed policies
    reason: Completed
```

```
      status: "True"
      type: Succeeded 3
    managedPoliciesForUpgrade:
    - name: policy1-common-cluster-version-policy
      namespace: default
    - name: policy2-common-pao-sub-policy
      namespace: default
    remediationPlan:
    - - spoke1
    - - spoke4
    status:
      completedAt: '2022-11-18T16:27:16Z'
      startedAt: '2022-11-18T16:27:15Z'
```

2 In the **Progressing** fields, the status is **false** as the update has completed; clusters are compliant with all the managed policies.

3 The **Succeeded** fields show that the validations completed successfully.

1 The **status** field includes a list of clusters and their respective statuses. The status of a cluster can be **complete** or **timedout**.

Sample ClusterGroupUpgrade CR in the timedout state

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  creationTimestamp: '2022-11-18T16:27:15Z'
  finalizers:
    - ran.openshift.io/cleanup-finalizer
  generation: 1
  name: talm-cgu
  namespace: talm-namespace
  resourceVersion: '40451823'
  uid: cca245a5-4bca-45fa-89c0-aa6af81a596c
spec:
  actions:
    afterCompletion:
      deleteObjects: true
    beforeEnable: {}
  backup: false
  clusters:
    - spoke1
    - spoke2
  enable: true
  managedPolicies:
    - talm-policy
  preCaching: false
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
status:
  clusters:
    - name: spoke1
      state: complete
  - currentPolicy: (1)
      name: talm-policy
      status: NonCompliant
    name: spoke2
    state: timedout
computedMaxConcurrency: 2
conditions:
  - lastTransitionTime: '2022-11-18T16:27:15Z'
    message: All selected clusters are valid
    reason: ClusterSelectionCompleted
    status: 'True'
    type: ClustersSelected
  - lastTransitionTime: '2022-11-18T16:27:15Z'
    message: Completed validation
    reason: ValidationCompleted
    status: 'True'
    type: Validated
  - lastTransitionTime: '2022-11-18T16:37:16Z'
    message: Policy remediation took too long
    reason: TimedOut
    status: 'False'
    type: Progressing
  - lastTransitionTime: '2022-11-18T16:37:16Z'
    message: Policy remediation took too long
    reason: TimedOut
    status: 'False'
    type: Succeeded (2)
managedPoliciesForUpgrade:
  - name: talm-policy
    namespace: talm-namespace
managedPoliciesNs:
  talm-policy: talm-namespace
remediationPlan:
  - - spoke1
    - spoke2
status:
      startedAt: '2022-11-18T16:27:15Z'
      completedAt: '2022-11-18T20:27:15Z'
```

(1) If a cluster's state is **timedout**, the **currentPolicy** field shows the name of the policy and the policy status.

(2) The status for **succeeded** is **false** and the message indicates that policy remediation took too long.

12.5.7. Blocking ClusterGroupUpgrade CRs

You can create multiple **ClusterGroupUpgrade** CRs and control their order of application.

For example, if you create **ClusterGroupUpgrade** CR C that blocks the start of **ClusterGroupUpgrade** CR A, then **ClusterGroupUpgrade** CR A cannot start until the status of **ClusterGroupUpgrade** CR C becomes **UpgradeComplete**.

One **ClusterGroupUpgrade** CR can have multiple blocking CRs. In this case, all the blocking CRs must complete before the upgrade for the current CR can start.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Provision one or more managed clusters.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Save the content of the **ClusterGroupUpgrade** CRs in the **cgu-a.yaml**, **cgu-b.yaml**, and **cgu-c.yaml** files.

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-a
  namespace: default
spec:
  blockingCRs: 1
  - name: cgu-c
    namespace: default
  clusters:
  - spoke1
  - spoke2
  - spoke3
  enable: false
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  - policy3-common-ptp-sub-policy
  remediationStrategy:
    canaries:
    - spoke1
    maxConcurrency: 2
    timeout: 240
status:
  conditions:
  - message: The ClusterGroupUpgrade CR is not enabled
    reason: UpgradeNotStarted
    status: "False"
    type: Ready
  managedPoliciesForUpgrade:
  - name: policy1-common-cluster-version-policy
    namespace: default
  - name: policy2-common-pao-sub-policy
    namespace: default
  - name: policy3-common-ptp-sub-policy
    namespace: default
  placementBindings:
  - cgu-a-policy1-common-cluster-version-policy
  - cgu-a-policy2-common-pao-sub-policy
  - cgu-a-policy3-common-ptp-sub-policy
  placementRules:
```

```
  - cgu-a-policy1-common-cluster-version-policy
  - cgu-a-policy2-common-pao-sub-policy
  - cgu-a-policy3-common-ptp-sub-policy
  remediationPlan:
  - - spoke1
  - - spoke2
```

1 Defines the blocking CRs. The **cgu-a** update cannot start until **cgu-c** is complete.

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-b
  namespace: default
spec:
  blockingCRs: 1
  - name: cgu-a
    namespace: default
  clusters:
  - spoke4
  - spoke5
  enable: false
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  - policy3-common-ptp-sub-policy
  - policy4-common-sriov-sub-policy
  remediationStrategy:
    maxConcurrency: 1
    timeout: 240
status:
  conditions:
  - message: The ClusterGroupUpgrade CR is not enabled
    reason: UpgradeNotStarted
    status: "False"
    type: Ready
  managedPoliciesForUpgrade:
  - name: policy1-common-cluster-version-policy
    namespace: default
  - name: policy2-common-pao-sub-policy
    namespace: default
  - name: policy3-common-ptp-sub-policy
    namespace: default
  - name: policy4-common-sriov-sub-policy
    namespace: default
  placementBindings:
  - cgu-b-policy1-common-cluster-version-policy
  - cgu-b-policy2-common-pao-sub-policy
  - cgu-b-policy3-common-ptp-sub-policy
  - cgu-b-policy4-common-sriov-sub-policy
  placementRules:
  - cgu-b-policy1-common-cluster-version-policy
  - cgu-b-policy2-common-pao-sub-policy
  - cgu-b-policy3-common-ptp-sub-policy
  - cgu-b-policy4-common-sriov-sub-policy
  remediationPlan:
  - - spoke4
  - - spoke5
  status: {}
```

1 The **cgu-b** update cannot start until **cgu-a** is complete.

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-c
  namespace: default
spec: 1
  clusters:
  - spoke6
  enable: false
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  - policy3-common-ptp-sub-policy
  - policy4-common-sriov-sub-policy
  remediationStrategy:
    maxConcurrency: 1
    timeout: 240
status:
  conditions:
  - message: The ClusterGroupUpgrade CR is not enabled
    reason: UpgradeNotStarted
    status: "False"
    type: Ready
  managedPoliciesCompliantBeforeUpgrade:
  - policy2-common-pao-sub-policy
  - policy3-common-ptp-sub-policy
  managedPoliciesForUpgrade:
  - name: policy1-common-cluster-version-policy
    namespace: default
  - name: policy4-common-sriov-sub-policy
    namespace: default
  placementBindings:
  - cgu-c-policy1-common-cluster-version-policy
  - cgu-c-policy4-common-sriov-sub-policy
  placementRules:
  - cgu-c-policy1-common-cluster-version-policy
  - cgu-c-policy4-common-sriov-sub-policy
  remediationPlan:
  - - spoke6
  status: {}
```

1 The **cgu-c** update does not have any blocking CRs. TALM starts the **cgu-c** update when the **enable** field is set to **true**.

2. Create the **ClusterGroupUpgrade** CRs by running the following command for each relevant CR:

```
$ oc apply -f <name>.yaml
```

3. Start the update process by running the following command for each relevant CR:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/<name> \
--type merge -p '{"spec":{"enable":true}}'
```

The following examples show **ClusterGroupUpgrade** CRs where the **enable** field is set to **true**:

Example for cgu-a with blocking CRs

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-a
  namespace: default
spec:
  blockingCRs:
  - name: cgu-c
    namespace: default
  clusters:
  - spoke1
  - spoke2
  - spoke3
  enable: true
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  - policy3-common-ptp-sub-policy
  remediationStrategy:
    canaries:
    - spoke1
    maxConcurrency: 2
    timeout: 240
status:
  conditions:
  - message: 'The ClusterGroupUpgrade CR is blocked by other CRs that have not yet
      completed: [cgu-c]' 1
    reason: UpgradeCannotStart
    status: "False"
    type: Ready
  managedPoliciesForUpgrade:
  - name: policy1-common-cluster-version-policy
    namespace: default
  - name: policy2-common-pao-sub-policy
    namespace: default
  - name: policy3-common-ptp-sub-policy
    namespace: default
  placementBindings:
  - cgu-a-policy1-common-cluster-version-policy
  - cgu-a-policy2-common-pao-sub-policy
  - cgu-a-policy3-common-ptp-sub-policy
  placementRules:
  - cgu-a-policy1-common-cluster-version-policy
  - cgu-a-policy2-common-pao-sub-policy
  - cgu-a-policy3-common-ptp-sub-policy
  remediationPlan:
  - - spoke1
  - - spoke2
  status: {}
```

1 Shows the list of blocking CRs.

Example for **cgu-b** with blocking CRs

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-b
  namespace: default
spec:
  blockingCRs:
  - name: cgu-a
    namespace: default
  clusters:
  - spoke4
  - spoke5
  enable: true
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  - policy3-common-ptp-sub-policy
  - policy4-common-sriov-sub-policy
  remediationStrategy:
    maxConcurrency: 1
    timeout: 240
status:
  conditions:
  - message: 'The ClusterGroupUpgrade CR is blocked by other CRs that have not yet
      completed: [cgu-a]' 1
    reason: UpgradeCannotStart
    status: "False"
    type: Ready
  managedPoliciesForUpgrade:
  - name: policy1-common-cluster-version-policy
    namespace: default
  - name: policy2-common-pao-sub-policy
    namespace: default
  - name: policy3-common-ptp-sub-policy
    namespace: default
  - name: policy4-common-sriov-sub-policy
    namespace: default
  placementBindings:
  - cgu-b-policy1-common-cluster-version-policy
  - cgu-b-policy2-common-pao-sub-policy
  - cgu-b-policy3-common-ptp-sub-policy
  - cgu-b-policy4-common-sriov-sub-policy
  placementRules:
  - cgu-b-policy1-common-cluster-version-policy
  - cgu-b-policy2-common-pao-sub-policy
  - cgu-b-policy3-common-ptp-sub-policy
  - cgu-b-policy4-common-sriov-sub-policy
  remediationPlan:
  - - spoke4
  - - spoke5
  status: {}
```

1 Shows the list of blocking CRs.

Example for **cgu-c** with blocking CRs

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-c
  namespace: default
spec:
  clusters:
  - spoke6
  enable: true
  managedPolicies:
  - policy1-common-cluster-version-policy
  - policy2-common-pao-sub-policy
  - policy3-common-ptp-sub-policy
  - policy4-common-sriov-sub-policy
  remediationStrategy:
    maxConcurrency: 1
    timeout: 240
status:
  conditions:
  - message: The ClusterGroupUpgrade CR has upgrade policies that are still non compliant
1
    reason: UpgradeNotCompleted
    status: "False"
    type: Ready
  managedPoliciesCompliantBeforeUpgrade:
  - policy2-common-pao-sub-policy
  - policy3-common-ptp-sub-policy
  managedPoliciesForUpgrade:
  - name: policy1-common-cluster-version-policy
    namespace: default
  - name: policy4-common-sriov-sub-policy
    namespace: default
  placementBindings:
  - cgu-c-policy1-common-cluster-version-policy
  - cgu-c-policy4-common-sriov-sub-policy
  placementRules:
  - cgu-c-policy1-common-cluster-version-policy
  - cgu-c-policy4-common-sriov-sub-policy
  remediationPlan:
  - - spoke6
  status:
    currentBatch: 1
    remediationPlanForBatch:
      spoke6: 0
```

1 The **cgu-c** update does not have any blocking CRs.

12.6. UPDATE POLICIES ON MANAGED CLUSTERS

The Topology Aware Lifecycle Manager (TALM) remediates a set of **inform** policies for the clusters specified in the **ClusterGroupUpgrade** custom resource (CR). TALM remediates **inform** policies by controlling the **remediationAction** specification in a **Policy** CR through the **bindingOverrides.remediationAction** and **subFilter** specifications in the **PlacementBinding** CR. Each policy has its own corresponding RHACM placement rule and RHACM placement binding.

One by one, TALM adds each cluster from the current batch to the placement rule that corresponds with the applicable managed policy. If a cluster is already compliant with a policy, TALM skips applying that policy on the compliant cluster. TALM then moves on to applying the next policy to the non-compliant cluster. After TALM completes the updates in a batch, all clusters are removed from the placement rules associated with the policies. Then, the update of the next batch starts.

If a spoke cluster does not report any compliant state to RHACM, the managed policies on the hub cluster can be missing status information that TALM needs. TALM handles these cases in the following ways:

- If a policy's **status.compliant** field is missing, TALM ignores the policy and adds a log entry. Then, TALM continues looking at the policy's **status.status** field.
- If a policy's **status.status** is missing, TALM produces an error.
- If a cluster's compliance status is missing in the policy's **status.status** field, TALM considers that cluster to be non-compliant with that policy.

The **ClusterGroupUpgrade** CR's **batchTimeoutAction** determines what happens if an upgrade fails for a cluster. You can specify **continue** to skip the failing cluster and continue to upgrade other clusters, or specify **abort** to stop the policy remediation for all clusters. Once the timeout elapses, TALM removes all the resources it created to ensure that no further updates are made to clusters.

Example upgrade policy

```
apiVersion: policy.open-cluster-management.io/v1
kind: Policy
metadata:
  name: ocp-4.4.16.4
  namespace: platform-upgrade
spec:
  disabled: false
  policy-templates:
  - objectDefinition:
      apiVersion: policy.open-cluster-management.io/v1
      kind: ConfigurationPolicy
      metadata:
        name: upgrade
      spec:
        namespaceselector:
          exclude:
```

```
          - kube-*
          include:
          - '*'
        object-templates:
        - complianceType: musthave
          objectDefinition:
            apiVersion: config.openshift.io/v1
            kind: ClusterVersion
            metadata:
              name: version
            spec:
              channel: stable-4.16
              desiredUpdate:
                version: 4.4.16.4
              upstream: https://api.openshift.com/api/upgrades_info/v1/graph
            status:
              history:
                - state: Completed
                  version: 4.4.16.4
        remediationAction: inform
        severity: low
  remediationAction: inform
```

For more information about RHACM policies, see Policy overview.

Additional resources

- About the PolicyGenerator CRD

12.6.1. Configuring Operator subscriptions for managed clusters that you install with TALM

Topology Aware Lifecycle Manager (TALM) can only approve the install plan for an Operator if the **Subscription** custom resource (CR) of the Operator contains the **status.state.AtLatestKnown** field.

Procedure

1. Add the **status.state.AtLatestKnown** field to the **Subscription** CR of the Operator:

   Example Subscription CR

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: cluster-logging
  namespace: openshift-logging
  annotations:
    ran.openshift.io/ztp-deploy-wave: "2"
spec:
  channel: "stable"
  name: cluster-logging
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown (1)
```

(1) The **status.state: AtLatestKnown** field is used for the latest Operator version available from the Operator catalog.

NOTE

When a new version of the Operator is available in the registry, the associated policy becomes non-compliant.

2. Apply the changed **Subscription** policy to your managed clusters with a **ClusterGroupUpgrade** CR.

12.6.2. Applying update policies to managed clusters

You can update your managed clusters by applying your policies.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- TALM 4.16 requires RHACM 2.9 or later.
- Provision one or more managed clusters.
- Log in as a user with **cluster-admin** privileges.
- Create RHACM policies in the hub cluster.

Procedure

1. Save the contents of the **ClusterGroupUpgrade** CR in the **cgu-1.yaml** file.

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-1
  namespace: default
spec:
  managedPolicies: (1)
    - policy1-common-cluster-version-policy
    - policy2-common-nto-sub-policy
    - policy3-common-ptp-sub-policy
    - policy4-common-sriov-sub-policy
  enable: false
  clusters: (2)
  - spoke1
  - spoke2
  - spoke5
  - spoke6
  remediationStrategy:
    maxConcurrency: 2 3
    timeout: 240 4
  batchTimeoutAction: 5
```

1 The name of the policies to apply.

2 The list of clusters to update.

3 The **maxConcurrency** field signifies the number of clusters updated at the same time.

4 The update timeout in minutes.

5 Controls what happens if a batch times out. Possible values are **abort** or **continue**. If unspecified, the default is **continue**.

2. Create the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc create -f cgu-1.yaml
```

   a. Check if the **ClusterGroupUpgrade** CR was created in the hub cluster by running the following command:

   ```
   $ oc get cgu --all-namespaces
   ```

   Example output

   ```
   NAMESPACE   NAME  AGE  STATE      DETAILS
   default     cgu-1 8m55 NotEnabled Not Enabled
   ```

   b. Check the status of the update by running the following command:

   ```
   $ oc get cgu -n default cgu-1 -ojsonpath='{.status}' | jq
   ```

   Example output

   ```
   {
     "computedMaxConcurrency": 2,
     "conditions": [
       {
         "lastTransitionTime": "2022-02-25T15:34:07Z",
         "message": "Not enabled", 1
         "reason": "NotEnabled",
         "status": "False",
         "type": "Progressing"
       }
     ],
     "managedPoliciesContent": {
       "policy1-common-cluster-version-policy": "null",
       "policy2-common-nto-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"node-tuning-
   operator\",\"namespace\":\"openshift-cluster-node-tuning-operator\"}]",
       "policy3-common-ptp-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"ptp-operator-
   subscription\",\"namespace\":\"openshift-ptp\"}]",
       "policy4-common-sriov-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"sriov-network-
   ```

```
operator-subscription\",\"namespace\":\"openshift-sriov-network-operator\"}]"
  },
  "managedPoliciesForUpgrade": [
    {
      "name": "policy1-common-cluster-version-policy",
      "namespace": "default"
    },
    {
      "name": "policy2-common-nto-sub-policy",
      "namespace": "default"
    },
    {
      "name": "policy3-common-ptp-sub-policy",
      "namespace": "default"
    },
    {
      "name": "policy4-common-sriov-sub-policy",
      "namespace": "default"
    }
  ],
  "managedPoliciesNs": {
    "policy1-common-cluster-version-policy": "default",
    "policy2-common-nto-sub-policy": "default",
    "policy3-common-ptp-sub-policy": "default",
    "policy4-common-sriov-sub-policy": "default"
  },
  "placementBindings": [
    "cgu-policy1-common-cluster-version-policy",
    "cgu-policy2-common-nto-sub-policy",
    "cgu-policy3-common-ptp-sub-policy",
    "cgu-policy4-common-sriov-sub-policy"
  ],
  "placementRules": [
    "cgu-policy1-common-cluster-version-policy",
    "cgu-policy2-common-nto-sub-policy",
    "cgu-policy3-common-ptp-sub-policy",
    "cgu-policy4-common-sriov-sub-policy"
  ],
  "remediationPlan": [
    [
      "spoke1",
      "spoke2"
    ],
    [
      "spoke5",
      "spoke6"
    ]
  ],
  "status": {}
}
```

1 The **spec.enable** field in the **ClusterGroupUpgrade** CR is set to **false**.

3. Change the value of the **spec.enable** field to **true** by running the following command:

```
$ oc --namespace=default patch clustergroupupgrade.ran.openshift.io/cgu-1 \
--patch '{"spec":{"enable":true}}' --type=merge
```

Verification

1. Check the status of the update by running the following command:

```
$ oc get cgu -n default cgu-1 -ojsonpath='{.status}' | jq
```

Example output

```
{
  "computedMaxConcurrency": 2,
  "conditions": [ 1
    {
      "lastTransitionTime": "2022-02-25T15:33:07Z",
      "message": "All selected clusters are valid",
      "reason": "ClusterSelectionCompleted",
      "status": "True",
      "type": "ClustersSelected"
    },
    {
      "lastTransitionTime": "2022-02-25T15:33:07Z",
      "message": "Completed validation",
      "reason": "ValidationCompleted",
      "status": "True",
      "type": "Validated"
    },
    {
      "lastTransitionTime": "2022-02-25T15:34:07Z",
      "message": "Remediating non-compliant policies",
      "reason": "InProgress",
      "status": "True",
      "type": "Progressing"
    }
  ],
  "managedPoliciesContent": {
    "policy1-common-cluster-version-policy": "null",
    "policy2-common-nto-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"node-tuning-
operator\",\"namespace\":\"openshift-cluster-node-tuning-operator\"}]",
    "policy3-common-ptp-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"ptp-operator-
subscription\",\"namespace\":\"openshift-ptp\"}]",
    "policy4-common-sriov-sub-policy": "[{\"kind\":\"Subscription\",\"name\":\"sriov-network-
operator-subscription\",\"namespace\":\"openshift-sriov-network-operator\"}]"
  },
  "managedPoliciesForUpgrade": [
    {
      "name": "policy1-common-cluster-version-policy",
      "namespace": "default"
    },
    {
      "name": "policy2-common-nto-sub-policy",
      "namespace": "default"
    },
      {
        "name": "policy3-common-ptp-sub-policy",
        "namespace": "default"
      },
      {
        "name": "policy4-common-sriov-sub-policy",
        "namespace": "default"
      }
    ],
    "managedPoliciesNs": {
      "policy1-common-cluster-version-policy": "default",
      "policy2-common-nto-sub-policy": "default",
      "policy3-common-ptp-sub-policy": "default",
      "policy4-common-sriov-sub-policy": "default"
    },
    "placementBindings": [
      "cgu-policy1-common-cluster-version-policy",
      "cgu-policy2-common-nto-sub-policy",
      "cgu-policy3-common-ptp-sub-policy",
      "cgu-policy4-common-sriov-sub-policy"
    ],
    "placementRules": [
      "cgu-policy1-common-cluster-version-policy",
      "cgu-policy2-common-nto-sub-policy",
      "cgu-policy3-common-ptp-sub-policy",
      "cgu-policy4-common-sriov-sub-policy"
    ],
    "remediationPlan": [
      [
        "spoke1",
        "spoke2"
      ],
      [
        "spoke5",
        "spoke6"
      ]
    ],
    "status": {
      "currentBatch": 1,
      "currentBatchRemediationProgress": {
         "spoke1": {
            "policyIndex": 1,
            "state": "InProgress"
         },
         "spoke2": {
            "policyIndex": 1,
            "state": "InProgress"
         }
      },
      "currentBatchStartedAt": "2022-02-25T15:54:16Z",
      "startedAt": "2022-02-25T15:54:16Z"
    }
  }
```

1. Reflects the update progress of the current batch. Run this command again to receive updated information about the progress.

2. Check the status of the policies by running the following command:

   ```
   oc get policies -A
   ```

   Example output

   ```
   NAMESPACE   NAME                                          REMEDIATION ACTION   COMPLIANCE
   STATE     AGE
   spoke1    default.policy1-common-cluster-version-policy enforce              Compliant
   18m
   spoke1    default.policy2-common-nto-sub-policy         enforce              NonCompliant
   18m
   spoke2    default.policy1-common-cluster-version-policy enforce              Compliant
   18m
   spoke2    default.policy2-common-nto-sub-policy         enforce              NonCompliant
   18m
   spoke5    default.policy3-common-ptp-sub-policy         inform               NonCompliant
   18m
   spoke5    default.policy4-common-sriov-sub-policy       inform               NonCompliant
   18m
   spoke6    default.policy3-common-ptp-sub-policy         inform               NonCompliant
   18m
   spoke6    default.policy4-common-sriov-sub-policy       inform               NonCompliant
   18m
   default   policy1-common-ptp-sub-policy                 inform               Compliant          18m
   default   policy2-common-sriov-sub-policy               inform               NonCompliant       18m
   default   policy3-common-ptp-sub-policy                 inform               NonCompliant       18m
   default   policy4-common-sriov-sub-policy               inform               NonCompliant       18m
   ```

   - The **spec.remediationAction** value changes to **enforce** for the child policies applied to the clusters from the current batch.
   - The **spec.remedationAction** value remains **inform** for the child policies in the rest of the clusters.
   - After the batch is complete, the **spec.remediationAction** value changes back to **inform** for the enforced child policies.

3. If the policies include Operator subscriptions, you can check the installation progress directly on the single-node cluster.

   a. Export the **KUBECONFIG** file of the single-node cluster you want to check the installation progress for by running the following command:

   ```
   $ export KUBECONFIG=<cluster_kubeconfig_absolute_path>
   ```

   b. Check all the subscriptions present on the single-node cluster and look for the one in the policy you are trying to install through the **ClusterGroupUpgrade** CR by running the following command:

   ```
   $ oc get subs -A | grep -i <subscription_name>
   ```

   Example output for cluster-logging policy

```
NAMESPACE                    NAME              PACKAGE              SOURCE
CHANNEL
openshift-logging           cluster-logging        cluster-logging           redhat-
operators   stable
```

4. If one of the managed policies includes a **ClusterVersion** CR, check the status of platform updates in the current batch by running the following command against the spoke cluster:

```
$ oc get clusterversion
```

Example output

```
NAME     VERSION   AVAILABLE   PROGRESSING   SINCE   STATUS
version   4.4.16.5      True          True           43s     Working towards 4.4.16.7: 71 of 735 done
(9% complete)
```

5. Check the Operator subscription by running the following command:

```
$ oc get subs -n <operator-namespace> <operator-subscription> -ojsonpath="{.status}"
```

6. Check the install plans present on the single-node cluster that is associated with the desired subscription by running the following command:

```
$ oc get installplan -n <subscription_namespace>
```

Example output for cluster-logging Operator

```
NAMESPACE                            NAME          CSV                              APPROVAL
APPROVED
openshift-logging                   install-6khtw   cluster-logging.5.3.3-4           Manual     true
1
```

1 The install plans have their **Approval** field set to **Manual** and their **Approved** field changes from **false** to **true** after TALM approves the install plan.

NOTE

When TALM is remediating a policy containing a subscription, it automatically approves any install plans attached to that subscription. Where multiple install plans are needed to get the operator to the latest known version, TALM might approve multiple install plans, upgrading through one or more intermediate versions to get to the final version.

7. Check if the cluster service version for the Operator of the policy that the **ClusterGroupUpgrade** is installing reached the **Succeeded** phase by running the following command:

```
$ oc get csv -n <operator_namespace>
```

Example output for OpenShift Logging Operator

```
NAME                  DISPLAY                    VERSION   REPLACES   PHASE
cluster-logging.5.4.2   Red Hat OpenShift Logging   5.4.2              Succeeded
```

12.7. CREATING A BACKUP OF CLUSTER RESOURCES BEFORE UPGRADE

For single-node OpenShift, the Topology Aware Lifecycle Manager (TALM) can create a backup of a deployment before an upgrade. If the upgrade fails, you can recover the previous version and restore a cluster to a working state without requiring a reprovision of applications.

To use the backup feature you first create a **ClusterGroupUpgrade** CR with the **backup** field set to **true**. To ensure that the contents of the backup are up to date, the backup is not taken until you set the **enable** field in the **ClusterGroupUpgrade** CR to **true**.

TALM uses the **BackupSucceeded** condition to report the status and reasons as follows:

- **true**
  Backup is completed for all clusters or the backup run has completed but failed for one or more clusters. If backup fails for any cluster, the update does not proceed for that cluster.

- **false**
  Backup is still in progress for one or more clusters or has failed for all clusters. The backup process running in the spoke clusters can have the following statuses:

  - **PreparingToStart**
    The first reconciliation pass is in progress. The TALM deletes any spoke backup namespace and hub view resources that have been created in a failed upgrade attempt.

  - **Starting**
    The backup prerequisites and backup job are being created.

  - **Active**
    The backup is in progress.

  - **Succeeded**
    The backup succeeded.

  - **BackupTimeout**
    Artifact backup is partially done.

  - **UnrecoverableError**
    The backup has ended with a non-zero exit code.

NOTE

If the backup of a cluster fails and enters the **BackupTimeout** or **UnrecoverableError** state, the cluster update does not proceed for that cluster. Updates to other clusters are not affected and continue.

12.7.1. Creating a ClusterGroupUpgrade CR with backup

You can create a backup of a deployment before an upgrade on single-node OpenShift clusters. If the upgrade fails you can use the **upgrade-recovery.sh** script generated by Topology Aware Lifecycle Manager (TALM) to return the system to its preupgrade state. The backup consists of the following items:

Cluster backup
: A snapshot of **etcd** and static pod manifests.

Content backup
: Backups of folders, for example, **/etc**, **/usr/local**, **/var/lib/kubelet**.

Changed files backup
: Any files managed by **machine-config** that have been changed.

Deployment
: A pinned **ostree** deployment.

Images (Optional)
: Any container images that are in use.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Provision one or more managed clusters.
- Log in as a user with **cluster-admin** privileges.
- Install Red Hat Advanced Cluster Management (RHACM).

NOTE

It is highly recommended that you create a recovery partition. The following is an example **SiteConfig** custom resource (CR) for a recovery partition of 50 GB:

```
nodes:
  - hostName: "node-1.example.com"
  role: "master"
  rootDeviceHints:
    hctl: "0:2:0:0"
    deviceName: /dev/disk/by-id/scsi-3600508b400105e210000900000490000
...
  #Disk /dev/disk/by-id/scsi-3600508b400105e210000900000490000:
  #893.3 GiB, 959119884288 bytes, 1873281024 sectors
  diskPartition:
    - device: /dev/disk/by-id/scsi-3600508b400105e210000900000490000
    partitions:
    - mount_point: /var/recovery
      size: 51200
      start: 800000
```

Procedure

1. Save the contents of the **ClusterGroupUpgrade** CR with the **backup** and **enable** fields set to **true** in the **clustergroupupgrades-group-du.yaml** file:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: du-upgrade-4918
  namespace: ztp-group-du-sno
spec:
  preCaching: true
  backup: true
  clusters:
  - cnfdb1
  - cnfdb2
  enable: true
  managedPolicies:
  - du-upgrade-platform-upgrade
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
```

2. To start the update, apply the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f clustergroupupgrades-group-du.yaml
```

Verification

- Check the status of the upgrade in the hub cluster by running the following command:

```
$ oc get cgu -n ztp-group-du-sno du-upgrade-4918 -o jsonpath='{.status}'
```

Example output

```
{
    "backup": {
        "clusters": [
            "cnfdb2",
            "cnfdb1"
    ],
    "status": {
        "cnfdb1": "Succeeded",
        "cnfdb2": "Failed" 1
    }
},
"computedMaxConcurrency": 1,
"conditions": [
    {
        "lastTransitionTime": "2022-04-05T10:37:19Z",
        "message": "Backup failed for 1 cluster", 2
        "reason": "PartiallyDone", 3
        "status": "True", 4
        "type": "Succeeded"
    }
],
"precaching": {
    "spec": {}
},
"status": {}
```

1. Backup has failed for one cluster.
2. The message confirms that the backup failed for one cluster.
3. The backup was partially successful.
4. The backup process has finished.

12.7.2. Recovering a cluster after a failed upgrade

If an upgrade of a cluster fails, you can manually log in to the cluster and use the backup to return the cluster to its preupgrade state. There are two stages:

Rollback

If the attempted upgrade included a change to the platform OS deployment, you must roll back to the previous version before running the recovery script.

IMPORTANT

A rollback is only applicable to upgrades from TALM and single-node OpenShift. This process does not apply to rollbacks from any other upgrade type.

Recovery

The recovery shuts down containers and uses files from the backup partition to relaunch containers and restore clusters.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Provision one or more managed clusters.
- Install Red Hat Advanced Cluster Management (RHACM).
- Log in as a user with **cluster-admin** privileges.
- Run an upgrade that is configured for backup.

Procedure

1. Delete the previously created **ClusterGroupUpgrade** custom resource (CR) by running the following command:

```
$ oc delete cgu/du-upgrade-4918 -n ztp-group-du-sno
```

2. Log in to the cluster that you want to recover.

3. Check the status of the platform OS deployment by running the following command:

```
$ ostree admin status
```

Example outputs

```
[root@lab-test-spoke2-node-0 core]# ostree admin status
* rhcos c038a8f08458bbed83a77ece033ad3c55597e3f64edad66ea12fda18cbdceaf9.0
    Version: 49.84.202202230006-0
    Pinned: yes (1)
    origin refspec:
c038a8f08458bbed83a77ece033ad3c55597e3f64edad66ea12fda18cbdceaf9
```

(1) The current deployment is pinned. A platform OS deployment rollback is not necessary.

```
[root@lab-test-spoke2-node-0 core]# ostree admin status
* rhcos f750ff26f2d5550930ccbe17af61af47daafc8018cd9944f2a3a6269af26b0fa.0
    Version: 410.84.202204050541-0
    origin refspec: f750ff26f2d5550930ccbe17af61af47daafc8018cd9944f2a3a6269af26b0fa
rhcos ad8f159f9dc4ea7e773fd9604c9a16be0fe9b266ae800ac8470f63abc39b52ca.0
(rollback) (1)
    Version: 410.84.202203290245-0
    Pinned: yes (2)
    origin refspec:
ad8f159f9dc4ea7e773fd9604c9a16be0fe9b266ae800ac8470f63abc39b52ca
```

(1) This platform OS deployment is marked for rollback.

(2) The previous deployment is pinned and can be rolled back.

4. To trigger a rollback of the platform OS deployment, run the following command:

```
$ rpm-ostree rollback -r
```

5. The first phase of the recovery shuts down containers and restores files from the backup partition to the targeted directories. To begin the recovery, run the following command:

```
$ /var/recovery/upgrade-recovery.sh
```

6. When prompted, reboot the cluster by running the following command:

```
$ systemctl reboot
```

7. After the reboot, restart the recovery by running the following command:

```
$ /var/recovery/upgrade-recovery.sh  --resume
```

NOTE

If the recovery utility fails, you can retry with the **--restart** option:

```
$ /var/recovery/upgrade-recovery.sh --restart
```

Verification

- To check the status of the recovery run the following command:

```
$ oc get clusterversion,nodes,clusteroperator
```

Example output

```
NAME                                  VERSION   AVAILABLE   PROGRESSING   SINCE
STATUS
clusterversion.config.openshift.io/version   4.4.16.23   True      False       86d     Cluster
version is 4.4.16.23 (1)


NAME                      STATUS   ROLES         AGE   VERSION
node/lab-test-spoke1-node-0   Ready    master,worker   86d   v1.22.3+b93fd35 (2)

NAME                                              VERSION   AVAILABLE
PROGRESSING   DEGRADED   SINCE   MESSAGE
clusteroperator.config.openshift.io/authentication                  4.4.16.23   True
False         False      2d7h   (3)
clusteroperator.config.openshift.io/baremetal                      4.4.16.23   True       False
False      86d


..............
```

(1) The cluster version is available and has the correct version.

(2) The node status is **Ready**.

(3) The **ClusterOperator** object's availability is **True**.

12.8. USING THE CONTAINER IMAGE PRE-CACHE FEATURE

Single-node OpenShift clusters might have limited bandwidth to access the container image registry, which can cause a timeout before the updates are completed.

NOTE

The time of the update is not set by TALM. You can apply the **ClusterGroupUpgrade** CR at the beginning of the update by manual application or by external automation.

The container image pre-caching starts when the **preCaching** field is set to **true** in the **ClusterGroupUpgrade** CR.

TALM uses the **PrecacheSpecValid** condition to report status information as follows:

- **true**
  The pre-caching spec is valid and consistent.
- **false**
  The pre-caching spec is incomplete.

TALM uses the **PrecachingSucceeded** condition to report status information as follows:

- **true**

TALM has concluded the pre-caching process. If pre-caching fails for any cluster, the update fails for that cluster but proceeds for all other clusters. A message informs you if pre-caching has failed for any clusters.

- **false**
  Pre-caching is still in progress for one or more clusters or has failed for all clusters.

After a successful pre-caching process, you can start remediating policies. The remediation actions start when the **enable** field is set to **true**. If there is a pre-caching failure on a cluster, the upgrade fails for that cluster. The upgrade process continues for all other clusters that have a successful pre-cache.

The pre-caching process can be in the following statuses:

- **NotStarted**
  This is the initial state all clusters are automatically assigned to on the first reconciliation pass of the **ClusterGroupUpgrade** CR. In this state, TALM deletes any pre-caching namespace and hub view resources of spoke clusters that remain from previous incomplete updates. TALM then creates a new **ManagedClusterView** resource for the spoke pre-caching namespace to verify its deletion in the **PrecachePreparing** state.
- **PreparingToStart**
  Cleaning up any remaining resources from previous incomplete updates is in progress.
- **Starting**
  Pre-caching job prerequisites and the job are created.
- **Active**
  The job is in "Active" state.
- **Succeeded**
  The pre-cache job succeeded.
- **PrecacheTimeout**
  The artifact pre-caching is partially done.
- **UnrecoverableError**
  The job ends with a non-zero exit code.

12.8.1. Using the container image pre-cache filter

The pre-cache feature typically downloads more images than a cluster needs for an update. You can control which pre-cache images are downloaded to a cluster. This decreases download time, and saves bandwidth and storage.

You can see a list of all images to be downloaded using the following command:

```
$ oc adm release info <ocp-version>
```

The following **ConfigMap** example shows how you can exclude images using the **excludePrecachePatterns** field.

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster-group-upgrade-overrides
```

```
data:
  excludePrecachePatterns: |
    azure (1)
    aws
    vsphere
    alibaba
```

(1) TALM excludes all images with names that include any of the patterns listed here.

12.8.2. Creating a ClusterGroupUpgrade CR with pre-caching

For single-node OpenShift, the pre-cache feature allows the required container images to be present on the spoke cluster before the update starts.

NOTE

For pre-caching, TALM uses the **spec.remediationStrategy.timeout** value from the **ClusterGroupUpgrade** CR. You must set a **timeout** value that allows sufficient time for the pre-caching job to complete. When you enable the **ClusterGroupUpgrade** CR after pre-caching has completed, you can change the **timeout** value to a duration that is appropriate for the update.

Prerequisites

- Install the Topology Aware Lifecycle Manager (TALM).
- Provision one or more managed clusters.
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Save the contents of the **ClusterGroupUpgrade** CR with the **preCaching** field set to **true** in the **clustergroupupgrades-group-du.yaml** file:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: du-upgrade-4918
  namespace: ztp-group-du-sno
spec:
  preCaching: true (1)
  clusters:
  - cnfdb1
  - cnfdb2
  enable: false
  managedPolicies:
  - du-upgrade-platform-upgrade
  remediationStrategy:
    maxConcurrency: 2
    timeout: 240
```

(1) The **preCaching** field is set to **true**, which enables TALM to pull the container images before starting the update.

2. When you want to start pre-caching, apply the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc apply -f clustergroupupgrades-group-du.yaml
```

Verification

1. Check if the **ClusterGroupUpgrade** CR exists in the hub cluster by running the following command:

```
$ oc get cgu -A
```

Example output

```
NAMESPACE         NAME              AGE   STATE        DETAILS
ztp-group-du-sno  du-upgrade-4918   10s   InProgress   Precaching is required and not done
(1)
```

(1) The CR is created.

2. Check the status of the pre-caching task by running the following command:

```
$ oc get cgu -n ztp-group-du-sno du-upgrade-4918 -o jsonpath='{.status}'
```

Example output

```
{
  "conditions": [
    {
      "lastTransitionTime": "2022-01-27T19:07:24Z",
      "message": "Precaching is required and not done",
      "reason": "InProgress",
      "status": "False",
      "type": "PrecachingSucceeded"
    },
    {
      "lastTransitionTime": "2022-01-27T19:07:34Z",
      "message": "Pre-caching spec is valid and consistent",
      "reason": "PrecacheSpecIsWellFormed",
      "status": "True",
      "type": "PrecacheSpecValid"
    }
  ],
  "precaching": {
    "clusters": [
      "cnfdb1" (1)
      "cnfdb2"
    ],
    "spec": {
      "platformImage": "image.example.io"},
    "status": {
      "cnfdb1": "Active"
      "cnfdb2": "Succeeded"}
    }
}
```

1 Displays the list of identified clusters.

3. Check the status of the pre-caching job by running the following command on the spoke cluster:

```
$ oc get jobs,pods -n openshift-talo-pre-cache
```

Example output

```
NAME                COMPLETIONS   DURATION   AGE
job.batch/pre-cache   0/1         3m10s      3m10s

NAME                    READY   STATUS    RESTARTS   AGE
pod/pre-cache--1-9bmlr   1/1     Running   0          3m10s
```

4. Check the status of the **ClusterGroupUpgrade** CR by running the following command:

```
$ oc get cgu -n ztp-group-du-sno du-upgrade-4918 -o jsonpath='{.status}'
```

Example output

```
"conditions": [
    {
      "lastTransitionTime": "2022-01-27T19:30:41Z",
      "message": "The ClusterGroupUpgrade CR has all clusters compliant with all the managed policies",
      "reason": "UpgradeCompleted",
      "status": "True",
      "type": "Ready"
    },
    {
      "lastTransitionTime": "2022-01-27T19:28:57Z",
      "message": "Precaching is completed",
      "reason": "PrecachingCompleted",
      "status": "True",
      "type": "PrecachingSucceeded" 1
    }
```

1 The pre-cache tasks are done.

12.9. TROUBLESHOOTING THE TOPOLOGY AWARE LIFECYCLE MANAGER

The Topology Aware Lifecycle Manager (TALM) is an OpenShift Container Platform Operator that remediates RHACM policies. When issues occur, use the **oc adm must-gather** command to gather details and logs and to take steps in debugging the issues.

For more information about related topics, see the following documentation:

- Red Hat Advanced Cluster Management for Kubernetes 2.4 Support Matrix
- Red Hat Advanced Cluster Management Troubleshooting
- The "Troubleshooting Operator issues" section

12.9.1. General troubleshooting

You can determine the cause of the problem by reviewing the following questions:

- Is the configuration that you are applying supported?
  - Are the RHACM and the OpenShift Container Platform versions compatible?
  - Are the TALM and RHACM versions compatible?
- Which of the following components is causing the problem?
  - Section 12.9.3, “Managed policies”
  - Section 12.9.4, “Clusters”
  - Section 12.9.5, “Remediation Strategy”
  - Section 12.9.6, “Topology Aware Lifecycle Manager”

To ensure that the **ClusterGroupUpgrade** configuration is functional, you can do the following:

1. Create the **ClusterGroupUpgrade** CR with the **spec.enable** field set to **false**.
2. Wait for the status to be updated and go through the troubleshooting questions.
3. If everything looks as expected, set the **spec.enable** field to **true** in the **ClusterGroupUpgrade** CR.

WARNING

After you set the **spec.enable** field to **true** in the **ClusterUpgradeGroup** CR, the update procedure starts and you cannot edit the CR’s **spec** fields anymore.

12.9.2. Cannot modify the ClusterUpgradeGroup CR

Issue

You cannot edit the **ClusterUpgradeGroup** CR after enabling the update.

Resolution

Restart the procedure by performing the following steps:

1. Remove the old **ClusterGroupUpgrade** CR by running the following command:

```
$ oc delete cgu -n <ClusterGroupUpgradeCR_namespace>
<ClusterGroupUpgradeCR_name>
```

2. Check and fix the existing issues with the managed clusters and policies.
    a. Ensure that all the clusters are managed clusters and available.
    b. Ensure that all the policies exist and have the **spec.remediationAction** field set to **inform**.
3. Create a new **ClusterGroupUpgrade** CR with the correct configurations.

```
$ oc apply -f <ClusterGroupUpgradeCR_YAML>
```

12.9.3. Managed policies

Checking managed policies on the system

Issue

You want to check if you have the correct managed policies on the system.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.spec.managedPolicies}'
```

Example output

```
["group-du-sno-validator-du-validator-policy", "policy2-common-nto-sub-policy", "policy3-common-
ptp-sub-policy"]
```

Checking remediationAction mode

Issue

You want to check if the **remediationAction** field is set to **inform** in the **spec** of the managed policies.

Resolution

Run the following command:

```
$ oc get policies --all-namespaces
```

Example output

```
NAMESPACE   NAME                                   REMEDIATION ACTION   COMPLIANCE
STATE   AGE
default     policy1-common-cluster-version-policy        inform             NonCompliant
5d21h
default     policy2-common-nto-sub-policy              inform            Compliant        5d21h
default     policy3-common-ptp-sub-policy              inform            NonCompliant      5d21h
default     policy4-common-sriov-sub-policy             inform            NonCompliant      5d21h
```

Checking policy compliance state

Issue

You want to check the compliance state of policies.

Resolution

Run the following command:

```
$ oc get policies --all-namespaces
```

Example output

```
NAMESPACE   NAME                                        REMEDIATION ACTION   COMPLIANCE
STATE   AGE
default     policy1-common-cluster-version-policy          inform               NonCompliant
5d21h
default     policy2-common-nto-sub-policy                inform               Compliant        5d21h
default     policy3-common-ptp-sub-policy                inform               NonCompliant     5d21h
default     policy4-common-sriov-sub-policy               inform               NonCompliant     5d21h
```

12.9.4. Clusters

Checking if managed clusters are present

Issue

You want to check if the clusters in the **ClusterGroupUpgrade** CR are managed clusters.

Resolution

Run the following command:

```
$ oc get managedclusters
```

Example output

```
NAME            HUB ACCEPTED   MANAGED CLUSTER URLS                  JOINED   AVAILABLE
AGE
local-cluster   true           https://api.hub.example.com:6443      True     Unknown    13d
spoke1          true           https://api.spoke1.example.com:6443    True     True       13d
spoke3          true           https://api.spoke3.example.com:6443    True     True       27h
```

1. Alternatively, check the TALM manager logs:

    a. Get the name of the TALM manager by running the following command:

    ```
    $ oc get pod -n openshift-operators
    ```

    Example output

    ```
    NAME                                                         READY   STATUS    RESTARTS   AGE
    cluster-group-upgrades-controller-manager-75bcc7484d-8k8xp   2/2     Running   0
    45m
    ```

b. Check the TALM manager logs by running the following command:

```
$ oc logs -n openshift-operators \
cluster-group-upgrades-controller-manager-75bcc7484d-8k8xp -c manager
```

Example output

```
ERROR controller-runtime.manager.controller.clustergroupupgrade Reconciler error
{"reconciler group": "ran.openshift.io", "reconciler kind": "ClusterGroupUpgrade",
"name": "lab-upgrade", "namespace": "default", "error": "Cluster spoke5555 is not a
ManagedCluster"} 1
sigs.k8s.io/controller-runtime/pkg/internal/controller.
(*Controller).processNextWorkItem
```

1 The error message shows that the cluster is not a managed cluster.

Checking if managed clusters are available

Issue

You want to check if the managed clusters specified in the **ClusterGroupUpgrade** CR are available.

Resolution

Run the following command:

```
$ oc get managedclusters
```

Example output

```
NAME            HUB ACCEPTED   MANAGED CLUSTER URLS                JOINED   AVAILABLE
AGE
local-cluster   true         https://api.hub.testlab.com:6443      True     Unknown     13d
spoke1          true         https://api.spoke1.testlab.com:6443    True     True       13d 1
spoke3          true         https://api.spoke3.testlab.com:6443    True     True       27h 2
```

1 2 The value of the **AVAILABLE** field is **True** for the managed clusters.

Checking clusterLabelSelector

Issue

You want to check if the **clusterLabelSelector** field specified in the **ClusterGroupUpgrade** CR matches at least one of the managed clusters.

Resolution

Run the following command:

```
$ oc get managedcluster --selector=upgrade=true 1
```

1 The label for the clusters you want to update is **upgrade:true**.

Example output

```
NAME          HUB ACCEPTED   MANAGED CLUSTER URLS                    JOINED
AVAILABLE   AGE
spoke1        true         https://api.spoke1.testlab.com:6443     True     True       13d
spoke3        true         https://api.spoke3.testlab.com:6443     True     True       27h
```

Checking if canary clusters are present

Issue

You want to check if the canary clusters are present in the list of clusters.

Example ClusterGroupUpgrade CR

```
spec:
    remediationStrategy:
        canaries:
        - spoke3
        maxConcurrency: 2
        timeout: 240
    clusterLabelSelectors:
      - matchLabels:
          upgrade: true
```

Resolution

Run the following commands:

```
$ oc get cgu lab-upgrade -ojsonpath='{.spec.clusters}'
```

Example output

```
["spoke1", "spoke3"]
```

1. Check if the canary clusters are present in the list of clusters that match **clusterLabelSelector** labels by running the following command:

```
$ oc get managedcluster --selector=upgrade=true
```

Example output

```
NAME          HUB ACCEPTED   MANAGED CLUSTER URLS   JOINED    AVAILABLE
AGE
spoke1        true         https://api.spoke1.testlab.com:6443   True     True       13d
spoke3        true         https://api.spoke3.testlab.com:6443   True     True       27h
```

NOTE

A cluster can be present in **spec.clusters** and also be matched by the **spec.clusterLabelSelector** label.

Checking the pre-caching status on spoke clusters

1. Check the status of pre-caching by running the following command on the spoke cluster:

```
$ oc get jobs,pods -n openshift-talo-pre-cache
```

12.9.5. Remediation Strategy

Checking if remediationStrategy is present in the ClusterGroupUpgrade CR

Issue

You want to check if the **remediationStrategy** is present in the **ClusterGroupUpgrade** CR.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.spec.remediationStrategy}'
```

Example output

```
{"maxConcurrency":2, "timeout":240}
```

Checking if maxConcurrency is specified in the ClusterGroupUpgrade CR

Issue

You want to check if the **maxConcurrency** is specified in the **ClusterGroupUpgrade** CR.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.spec.remediationStrategy.maxConcurrency}'
```

Example output

```
2
```

12.9.6. Topology Aware Lifecycle Manager

Checking condition message and status in the ClusterGroupUpgrade CR

Issue

You want to check the value of the **status.conditions** field in the **ClusterGroupUpgrade** CR.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.status.conditions}'
```

Example output

```
{"lastTransitionTime":"2022-02-17T22:25:28Z", "message":"Missing managed policies:[policyList]",
"reason":"NotAllManagedPoliciesExist", "status":"False", "type":"Validated"}
```

Checking if status.remediationPlan was computed

Issue

You want to check if **status.remediationPlan** is computed.

Resolution

Run the following command:

```
$ oc get cgu lab-upgrade -ojsonpath='{.status.remediationPlan}'
```

Example output

```
[["spoke2", "spoke3"]]
```

Errors in the TALM manager container

Issue

You want to check the logs of the manager container of TALM.

Resolution

Run the following command:

```
$ oc logs -n openshift-operators \
cluster-group-upgrades-controller-manager-75bcc7484d-8k8xp -c manager
```

Example output

```
ERROR controller-runtime.manager.controller.clustergroupupgrade Reconciler error {"reconciler
group": "ran.openshift.io", "reconciler kind": "ClusterGroupUpgrade", "name": "lab-upgrade",
"namespace": "default", "error": "Cluster spoke5555 is not a ManagedCluster"} 1
sigs.k8s.io/controller-runtime/pkg/internal/controller.(*Controller).processNextWorkItem
```

1 Displays the error.

Clusters are not compliant to some policies after a**ClusterGroupUpgrade** CR has completed

Issue

The policy compliance status that TALM uses to decide if remediation is needed has not yet fully updated for all clusters. This may be because:

- The CGU was run too soon after a policy was created or updated.
- The remediation of a policy affects the compliance of subsequent policies in the **ClusterGroupUpgrade** CR.

Resolution

Create and apply a new **ClusterGroupUpdate** CR with the same specification.

Auto-created **ClusterGroupUpgrade** CR in the GitOps ZTP workflow has no managed policies

Issue

If there are no policies for the managed cluster when the cluster becomes **Ready**, a **ClusterGroupUpgrade** CR with no policies is auto-created. Upon completion of the **ClusterGroupUpgrade** CR, the managed cluster is labeled as **ztp-done**. If the **PolicyGenerator** or **PolicyGenTemplate** CRs were not pushed to the Git repository within the required time after **SiteConfig** resources were pushed, this might result in no policies being available for the target cluster when the cluster became **Ready**.

Resolution

Verify that the policies you want to apply are available on the hub cluster, then create a **ClusterGroupUpgrade** CR with the required policies.

You can either manually create the **ClusterGroupUpgrade** CR or trigger auto-creation again. To trigger auto-creation of the **ClusterGroupUpgrade** CR, remove the **ztp-done** label from the cluster and delete the empty **ClusterGroupUpgrade** CR that was previously created in the **zip-install** namespace.

Pre-caching has failed

Issue

Pre-caching might fail for one of the following reasons:

- There is not enough free space on the node.
- For a disconnected environment, the pre-cache image has not been properly mirrored.
- There was an issue when creating the pod.

Resolution

1. To check if pre-caching has failed due to insufficient space, check the log of the pre-caching pod in the node.
   a. Find the name of the pod using the following command:
      ```
      $ oc get pods -n openshift-talo-pre-cache
      ```
   b. Check the logs to see if the error is related to insufficient space using the following command:
      ```
      $ oc logs -n openshift-talo-pre-cache <pod name>
      ```
2. If there is no log, check the pod status using the following command:
   ```
   $ oc describe pod -n openshift-talo-pre-cache <pod name>
   ```
3. If the pod does not exist, check the job status to see why it could not create a pod using the following command:
   ```
   $ oc describe job -n openshift-talo-pre-cache pre-cache
   ```

Additional resources

- OpenShift Container Platform Troubleshooting Operator Issues
- Updating managed policies with Topology Aware Lifecycle Manager
- About the PolicyGenerator CRD

CHAPTER 13. EXPANDING SINGLE-NODE OPENSHIFT CLUSTERS WITH GITOPS ZTP

You can expand single-node OpenShift clusters with GitOps Zero Touch Provisioning (ZTP). When you add worker nodes to single-node OpenShift clusters, the original single-node OpenShift cluster retains the control plane node role. Adding worker nodes does not require any downtime for the existing single-node OpenShift cluster.

NOTE

Although there is no specified limit on the number of worker nodes that you can add to a single-node OpenShift cluster, you must revaluate the reserved CPU allocation on the control plane node for the additional worker nodes.

If you require workload partitioning on the worker node, you must deploy and remediate the managed cluster policies on the hub cluster before installing the node. This way, the workload partitioning **MachineConfig** objects are rendered and associated with the **worker** machine config pool before the GitOps ZTP workflow applies the **MachineConfig** ignition file to the worker node.

It is recommended that you first remediate the policies, and then install the worker node. If you create the workload partitioning manifests after installing the worker node, you must drain the node manually and delete all the pods managed by daemon sets. When the managing daemon sets create the new pods, the new pods undergo the workload partitioning process.

IMPORTANT

Adding worker nodes to single-node OpenShift clusters with GitOps ZTP is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

Additional resources

- For more information about single-node OpenShift clusters tuned for vDU application deployments, see Reference configuration for deploying vDUs on single-node OpenShift .
- For more information about worker nodes, see Adding worker nodes to single-node OpenShift clusters.
- For information about removing a worker node from an expanded single-node OpenShift cluster, see Removing managed cluster nodes by using the command line interface .

13.1. APPLYING PROFILES TO THE WORKER NODE WITH POLICYGENERATOR OR POLICYGENTEMPLATE RESOURCES

You can configure the additional worker node with a DU profile.

You can apply a RAN distributed unit (DU) profile to the worker node cluster using the GitOps Zero

Touch Provisioning (ZTP) common, group, and site-specific **PolicyGenerator** or **PolicyGenTemplate** resources. The GitOps ZTP pipeline that is linked to the ArgoCD **policies** application includes the following CRs that you can find in the relevant **out/argocd/example** folder when you extract the **ztp-site-generate** container:

/acmpolicygenerator resources

- **acm-common-ranGen.yaml**
- **acm-group-du-sno-ranGen.yaml**
- **acm-example-sno-site.yaml**
- **ns.yaml**
- **kustomization.yaml**

/policygentemplates resources

- **common-ranGen.yaml**
- **group-du-sno-ranGen.yaml**
- **example-sno-site.yaml**
- **ns.yaml**
- **kustomization.yaml**

Configuring the DU profile on the worker node is considered an upgrade. To initiate the upgrade flow, you must update the existing policies or create additional ones. Then, you must create a **ClusterGroupUpgrade** CR to reconcile the policies in the group of clusters.

13.2. ENSURING PTP AND SR-IOV DAEMON SELECTOR COMPATIBILITY

If the DU profile was deployed using the GitOps Zero Touch Provisioning (ZTP) plugin version 4.11 or earlier, the PTP and SR-IOV Operators might be configured to place the daemons only on nodes labeled as **master**. This configuration prevents the PTP and SR-IOV daemons from operating on the worker node. If the PTP and SR-IOV daemon node selectors are incorrectly configured on your system, you must change the daemons before proceeding with the worker DU profile configuration.

Procedure

1. Check the daemon node selector settings of the PTP Operator on one of the spoke clusters:

```
$ oc get ptpoperatorconfig/default -n openshift-ptp -ojsonpath='{.spec}' | jq
```

Example output for PTP Operator

```
{"daemonNodeSelector":{"node-role.kubernetes.io/master":""}} (1)
```

(1) If the node selector is set to **master**, the spoke was deployed with the version of the GitOps ZTP plugin that requires changes.

2. Check the daemon node selector settings of the SR-IOV Operator on one of the spoke clusters:

   ```
   $ oc get sriovoperatorconfig/default -n \
   openshift-sriov-network-operator -ojsonpath='{.spec}' | jq
   ```

   Example output for SR-IOV Operator

   ```
   {"configDaemonNodeSelector":{"node-
   role.kubernetes.io/worker":""},"disableDrain":false,"enableInjector":true,"enableOperatorWebh
   ook":true} 1
   ```

   1 If the node selector is set to **master**, the spoke was deployed with the version of the GitOps ZTP plugin that requires changes.

3. In the group policy, add the following **complianceType** and **spec** entries:

   ```
   spec:
       - fileName: PtpOperatorConfig.yaml
         policyName: "config-policy"
         complianceType: mustonlyhave
         spec:
           daemonNodeSelector:
             node-role.kubernetes.io/worker: ""
       - fileName: SriovOperatorConfig.yaml
         policyName: "config-policy"
         complianceType: mustonlyhave
         spec:
           configDaemonNodeSelector:
             node-role.kubernetes.io/worker: ""
   ```

   IMPORTANT

   Changing the **daemonNodeSelector** field causes temporary PTP synchronization loss and SR-IOV connectivity loss.

4. Commit the changes in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.

13.3. PTP AND SR-IOV NODE SELECTOR COMPATIBILITY

The PTP configuration resources and SR-IOV network node policies use **node-role.kubernetes.io/master: ""** as the node selector. If the additional worker nodes have the same NIC configuration as the control plane node, the policies used to configure the control plane node can be reused for the worker nodes. However, the node selector must be changed to select both node types, for example with the **"node-role.kubernetes.io/worker"** label.

13.4. USING POLICYGENERATOR CRS TO APPLY WORKER NODE POLICIES TO WORKER NODES

You can create policies for worker nodes using **PolicyGenerator** CRs.

Procedure

1. Create the following **PolicyGenerator** CR:

```
apiVersion: policy.open-cluster-management.io/v1
kind: PolicyGenerator
metadata:
  name: example-sno-workers
placementBindingDefaults:
  name: example-sno-workers-placement-binding
policyDefaults:
  namespace: example-sno
  placement:
    labelSelector:
      matchExpressions:
        - key: sites
          operator: In
          values:
            - example-sno 1
  remediationAction: inform
  severity: low
  namespaceSelector:
    exclude:
      - kube-*
    include:
      - '*'
  evaluationInterval:
    compliant: 10m
    noncompliant: 10s
policies:
  - name: example-sno-workers-config-policy
    policyAnnotations:
      ran.openshift.io/ztp-deploy-wave: "10"
    manifests:
      - path: source-crs/MachineConfigGeneric.yaml 2
        patches:
          - metadata:
              labels:
                machineconfiguration.openshift.io/role: worker 3
              name: enable-workload-partitioning
            spec:
              config:
                storage:
                  files:
                    - contents:
                        source: data:text/plain;charset=utf-
8;base64,W2NyaW8ucnVudGltZS53b3JrbG9hZHMubWFuYWdlbWVudF0KYWN0aXZhdGlvbl
9hbm5vdGF0aW9uID0gInRhcmdldC53b3JrbG9hZC5vcGVuc2hpZnQuaW8vbWFuYWdlbWVu
dCIKYW5ub3RhdGlvbl9wcmVmaXggPSAicmVzb3VyY2VzLndvcmtsb2FkLm9wZW5zaGlmdC5
pbyIKcmVzb3VyY2VzID0geyAiY3B1c2hhcmVzIiA9IDAsICJjcHVzZXQiID0gIjAtMyIgfQo=
                      mode: 420
                      overwrite: true
                      path: /etc/crio/crio.conf.d/01-workload-partitioning
                      user:
                        name: root
                    - contents:
```

```
                source: data:text/plain;charset=utf-
8;base64,ewogICJtYW5hZ2VtZW50IjogewogICAgImNwdXNldCI6ICIwLTMiCiAgfQp9Cg==
               mode: 420
               overwrite: true
               path: /etc/kubernetes/openshift-workload-pinning
               user:
                name: root
    - path: source-crs/PerformanceProfile-MCP-worker.yaml
     patches:
      - metadata:
        name: openshift-worker-node-performance-profile
       spec:
        cpu: 4
          isolated: 4-47
          reserved: 0-3
        hugepages:
          defaultHugepagesSize: 1G
          pages:
            - count: 32
             size: 1G
        realTimeKernel:
          enabled: true
    - path: source-crs/TunedPerformancePatch-MCP-worker.yaml
     patches:
      - metadata:
        name: performance-patch-worker
       spec:
        profile:
          - data: |
           [main]
           summary=Configuration changes profile inherited from performance created
tuned
           include=openshift-node-performance-openshift-worker-node-performance-
profile
           [bootloader]
           cmdline_crash=nohz_full=4-47 5
           [sysctl]
           kernel.timer_migration=1
           [scheduler]
           group.ice-ptp=0:f:10:*:ice-ptp.*
           [service]
           service.stalld=start,enable
           service.chronyd=stop,disable
           name: performance-patch-worker
        recommend:
          - profile: performance-patch-worker
```

1 The policies are applied to all clusters with this label.

2 This generic **MachineConfig** CR is used to configure workload partitioning on the worker node.

3 The **MCP** field must be set to **worker**.

4 The **cpu.isolated** and **cpu.reserved** fields must be configured for each particular hardware platform.

5 The **cmdline_crash** CPU set must match the **cpu.isolated** set in the **PerformanceProfile** section.

A generic **MachineConfig** CR is used to configure workload partitioning on the worker node. You can generate the content of **crio** and **kubelet** configuration files.

2. Add the created policy template to the Git repository monitored by the ArgoCD **policies** application.
3. Add the policy in the **kustomization.yaml** file.
4. Commit the changes in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.
5. To remediate the new policies to your spoke cluster, create a TALM custom resource:

```
$ cat <<EOF | oc apply -f -
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: example-sno-worker-policies
  namespace: default
spec:
  backup: false
  clusters:
  - example-sno
  enable: true
  managedPolicies:
  - group-du-sno-config-policy
  - example-sno-workers-config-policy
  - example-sno-config-policy
  preCaching: false
  remediationStrategy:
    maxConcurrency: 1
EOF
```

13.5. USING POLICYGENTEMPLATE CRS TO APPLY WORKER NODE POLICIES TO WORKER NODES

You can create policies for worker nodes using **PolicyGenTemplate** CRs.

Procedure

1. Create the following **PolicyGenTemplate** CR:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-sno-workers"
  namespace: "example-sno"
spec:
  bindingRules:
    sites: "example-sno" 1
  mcp: "worker" 2
```

```
 sourceFiles:
  - fileName: MachineConfigGeneric.yaml 3
   policyName: "config-policy"
   metadata:
    labels:
     machineconfiguration.openshift.io/role: worker
    name: enable-workload-partitioning
   spec:
    config:
     storage:
      files:
      - contents:
        source: data:text/plain;charset=utf-
8;base64,W2NyaW8ucnVudGltZS53b3JrbG9hZHMubWFuYWdlbWVudF0KYWN0aXZhdGlvbl
9hbm5vdGF0aW9uID0gInRhcmdldC53b3JrbG9hZC5vcGVuc2hpZnQuaW8vbWFuYWdlbWVu
dCIKYW5ub3RhdGlvbl9wcmVmaXggPSAicmVzb3VyY2VzLndvcmtsb2FkLm9wZW5zaGlmdC5
pbyIKcmVzb3VyY2VzID0geyAiY3B1c2hhcmVzIiA9IDAsICJjcHVzZXQiID0gIjAtMyIgfQo=
       mode: 420
       overwrite: true
       path: /etc/crio/crio.conf.d/01-workload-partitioning
       user:
        name: root
      - contents:
        source: data:text/plain;charset=utf-
8;base64,ewogICJtYW5hZ2VtZW50IjogewogICAgImNwdXNldCI6ICIwLTMiCiAgfQp9Cg==
       mode: 420
       overwrite: true
       path: /etc/kubernetes/openshift-workload-pinning
       user:
        name: root
  - fileName: PerformanceProfile.yaml
   policyName: "config-policy"
   metadata:
    name: openshift-worker-node-performance-profile
   spec:
    cpu: 4
     isolated: "4-47"
     reserved: "0-3"
    hugepages:
     defaultHugepagesSize: 1G
     pages:
      - size: 1G
       count: 32
    realTimeKernel:
     enabled: true
  - fileName: TunedPerformancePatch.yaml
   policyName: "config-policy"
   metadata:
    name: performance-patch-worker
   spec:
    profile:
     - name: performance-patch-worker
      data: |
       [main]
       summary=Configuration changes profile inherited from performance created tuned
       include=openshift-node-performance-openshift-worker-node-performance-profile
```

```
          [bootloader]
          cmdline_crash=nohz_full=4-47 (5)
          [sysctl]
          kernel.timer_migration=1
          [scheduler]
          group.ice-ptp=0:f:10:*:ice-ptp.*
          [service]
          service.stalld=start,enable
          service.chronyd=stop,disable
      recommend:
      - profile: performance-patch-worker
```

1. The policies are applied to all clusters with this label.
2. The **MCP** field must be set to **worker**.
3. This generic **MachineConfig** CR is used to configure workload partitioning on the worker node.
4. The **cpu.isolated** and **cpu.reserved** fields must be configured for each particular hardware platform.
5. The **cmdline_crash** CPU set must match the **cpu.isolated** set in the **PerformanceProfile** section.

A generic **MachineConfig** CR is used to configure workload partitioning on the worker node. You can generate the content of **crio** and **kubelet** configuration files.

2. Add the created policy template to the Git repository monitored by the ArgoCD **policies** application.

3. Add the policy in the **kustomization.yaml** file.

4. Commit the changes in Git, and then push to the Git repository being monitored by the GitOps ZTP ArgoCD application.

5. To remediate the new policies to your spoke cluster, create a TALM custom resource:

```
$ cat <<EOF | oc apply -f -
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: example-sno-worker-policies
  namespace: default
spec:
  backup: false
  clusters:
  - example-sno
  enable: true
  managedPolicies:
  - group-du-sno-config-policy
  - example-sno-workers-config-policy
  - example-sno-config-policy
  preCaching: false
  remediationStrategy:
    maxConcurrency: 1
EOF
```

13.6. ADDING WORKER NODES TO SINGLE-NODE OPENSHIFT CLUSTERS WITH GITOPS ZTP

You can add one or more worker nodes to existing single-node OpenShift clusters to increase available CPU resources in the cluster.

Prerequisites

- Install and configure RHACM 2.6 or later in an OpenShift Container Platform 4.11 or later bare-metal hub cluster
- Install Topology Aware Lifecycle Manager in the hub cluster
- Install Red Hat OpenShift GitOps in the hub cluster
- Use the GitOps ZTP **ztp-site-generate** container image version 4.12 or later
- Deploy a managed single-node OpenShift cluster with GitOps ZTP
- Configure the Central Infrastructure Management as described in the RHACM documentation
- Configure the DNS serving the cluster to resolve the internal API endpoint **api-int.<cluster_name>.<base_domain>**

Procedure

1. If you deployed your cluster by using the **example-sno.yaml SiteConfig** manifest, add your new worker node to the **spec.clusters['example-sno'].nodes** list:

```
nodes:
- hostName: "example-node2.example.com"
  role: "worker"
  bmcAddress: "idrac-virtualmedia+https://[1111:2222:3333:4444::bbbb:1]/redfish/v1/Systems/System.Embedded.1"

  bmcCredentialsName:
    name: "example-node2-bmh-secret"
  bootMACAddress: "AA:BB:CC:DD:EE:11"
  bootMode: "UEFI"
  nodeNetwork:
    interfaces:
      - name: eno1
        macAddress: "AA:BB:CC:DD:EE:11"
    config:
      interfaces:
        - name: eno1
          type: ethernet
          state: up
          macAddress: "AA:BB:CC:DD:EE:11"
          ipv4:
            enabled: false
          ipv6:
            enabled: true
            address:
            - ip: 1111:2222:3333:4444::1
              prefix-length: 64
      dns-resolver:
        config:
          search:
          - example.com
          server:
          - 1111:2222:3333:4444::2
      routes:
        config:
        - destination: ::/0
          next-hop-interface: eno1
          next-hop-address: 1111:2222:3333:4444::1
          table-id: 254
```

2. Create a BMC authentication secret for the new host, as referenced by the **bmcCredentialsName** field in the **spec.nodes** section of your **SiteConfig** file:

```
apiVersion: v1
data:
  password: "password"
  username: "username"
kind: Secret
metadata:
  name: "example-node2-bmh-secret"
  namespace: example-sno
type: Opaque
```

3. Commit the changes in Git, and then push to the Git repository that is being monitored by the GitOps ZTP ArgoCD application.
When the ArgoCD **cluster** application synchronizes, two new manifests appear on the hub cluster generated by the GitOps ZTP plugin:
   - **BareMetalHost**
   - **NMStateConfig**

IMPORTANT

The **cpuset** field should not be configured for the worker node. Workload partitioning for worker nodes is added through management policies after the node installation is complete.

Verification

You can monitor the installation process in several ways.

- Check if the preprovisioning images are created by running the following command:

```
$ oc get ppimg -n example-sno
```

Example output

```
NAMESPACE     NAME          READY   REASON
example-sno   example-sno    True   ImageCreated
example-sno   example-node2  True   ImageCreated
```

- Check the state of the bare-metal hosts:

```
$ oc get bmh -n example-sno
```

Example output

```
NAME           STATE          CONSUMER   ONLINE   ERROR   AGE
example-sno    provisioned               true             69m
example-node2  provisioning              true             4m50s (1)
```

(1) The **provisioning** state indicates that node booting from the installation media is in progress.

- Continuously monitor the installation process:

  a. Watch the agent install process by running the following command:

```
$ oc get agent -n example-sno --watch
```

Example output

```
NAME                                   CLUSTER   APPROVED   ROLE     STAGE
671bc05d-5358-8940-ec12-d9ad22804faa   example-sno   true      master   Done
[...]
14fd821b-a35d-9cba-7978-00ddf535ff37   example-sno   true      worker   Starting
installation
14fd821b-a35d-9cba-7978-00ddf535ff37   example-sno   true      worker   Installing
14fd821b-a35d-9cba-7978-00ddf535ff37   example-sno   true      worker   Writing image
to disk
[...]
14fd821b-a35d-9cba-7978-00ddf535ff37   example-sno   true      worker   Waiting for
control plane
[...]
14fd821b-a35d-9cba-7978-00ddf535ff37   example-sno   true      worker   Rebooting
14fd821b-a35d-9cba-7978-00ddf535ff37   example-sno   true      worker   Done
```

  b. When the worker node installation is finished, the worker node certificates are approved automatically. At this point, the worker appears in the **ManagedClusterInfo** status. Run the following command to see the status:

```
$ oc get managedclusterinfo/example-sno -n example-sno -o \
jsonpath='{range .status.nodeList[*]}{.name}{"\t"}{.conditions}{"\t"}{.labels}{"\n"}{end}'
```

Example output

```
example-sno [{"status":"True","type":"Ready"}] {"node-
role.kubernetes.io/master":"","node-role.kubernetes.io/worker":""}
example-node2 [{"status":"True","type":"Ready"}] {"node-role.kubernetes.io/worker":""}
```

CHAPTER 14. PRE-CACHING IMAGES FOR SINGLE-NODE OPENSHIFT DEPLOYMENTS

In environments with limited bandwidth where you use the GitOps Zero Touch Provisioning (ZTP) solution to deploy a large number of clusters, you want to avoid downloading all the images that are required for bootstrapping and installing OpenShift Container Platform. The limited bandwidth at remote single-node OpenShift sites can cause long deployment times. The factory-precaching-cli tool allows you to pre-stage servers before shipping them to the remote site for ZTP provisioning.

The factory-precaching-cli tool does the following:

- Downloads the RHCOS rootfs image that is required by the minimal ISO to boot.
- Creates a partition from the installation disk labelled as **data**.
- Formats the disk in xfs.
- Creates a GUID Partition Table (GPT) data partition at the end of the disk, where the size of the partition is configurable by the tool.
- Copies the container images required to install OpenShift Container Platform.
- Copies the container images required by ZTP to install OpenShift Container Platform.
- Optional: Copies Day-2 Operators to the partition.

IMPORTANT

The factory-precaching-cli tool is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

14.1. GETTING THE FACTORY-PRECACHING-CLI TOOL

The factory-precaching-cli tool Go binary is publicly available in the {rds-first} tools container image. The factory-precaching-cli tool Go binary in the container image is executed on the server running an RHCOS live image using **podman**. If you are working in a disconnected environment or have a private registry, you need to copy the image there so you can download the image to the server.

Procedure

- Pull the factory-precaching-cli tool image by running the following command:

```
# podman pull quay.io/openshift-kni/telco-ran-tools:latest
```

Verification

- To check that the tool is available, query the current version of the factory-precaching-cli tool Go binary:

```
# podman run quay.io/openshift-kni/telco-ran-tools:latest -- factory-precaching-cli -v
```

Example output

```
factory-precaching-cli version 20221018.120852+main.feecf17
```

14.2. BOOTING FROM A LIVE OPERATING SYSTEM IMAGE

You can use the factory-precaching-cli tool with to boot servers where only one disk is available and external disk drive cannot be attached to the server.

WARNING

RHCOS requires the disk to not be in use when the disk is about to be written with an RHCOS image.

Depending on the server hardware, you can mount the RHCOS live ISO on the blank server using one of the following methods:

- Using the Dell RACADM tool on a Dell server.
- Using the HPONCFG tool on a HP server.
- Using the Redfish BMC API.

NOTE

It is recommended to automate the mounting procedure. To automate the procedure, you need to pull the required images and host them on a local HTTP server.

Prerequisites

- You powered up the host.
- You have network connectivity to the host.

PROCEDURE

This example procedure uses the Redfish BMC API to mount the RHCOS live ISO.

1. Mount the RHCOS live ISO:

   a. Check virtual media status:

   ```
   $ curl --globoff -H "Content-Type: application/json" -H \
   "Accept: application/json" -k -X GET --user ${username_password} \
   https://$BMC_ADDRESS/redfish/v1/Managers/Self/VirtualMedia/1 | python -m json.tool
   ```

b. Mount the ISO file as a virtual media:

```
$ curl --globoff -L -w "%{http_code} %{url_effective}\\n" -ku ${username_password} -H
"Content-Type: application/json" -H "Accept: application/json" -d '{"Image":
"http://[$HTTPd_IP]/RHCOS-live.iso"}' -X POST
https://$BMC_ADDRESS/redfish/v1/Managers/Self/VirtualMedia/1/Actions/VirtualMedia.Ins
ertMedia
```

c. Set the boot order to boot from the virtual media once:

```
$ curl --globoff  -L -w "%{http_code} %{url_effective}\\n"  -ku ${username_password}  -H
"Content-Type: application/json" -H "Accept: application/json" -d '{"Boot":{
"BootSourceOverrideEnabled": "Once", "BootSourceOverrideTarget": "Cd",
"BootSourceOverrideMode": "UEFI"}}' -X PATCH
https://$BMC_ADDRESS/redfish/v1/Systems/Self
```

2. Reboot and ensure that the server is booting from virtual media.

Additional resources

- For more information about the **butane** utility, see About Butane.
- For more information about creating a custom live RHCOS ISO, see Creating a custom live RHCOS ISO for remote server access.
- For more information about using the Dell RACADM tool, see Integrated Dell Remote Access Controller 9 RACADM CLI Guide.
- For more information about using the HP HPONCFG tool, see Using HPONCFG.
- For more information about using the Redfish BMC API, see Booting from an HTTP-hosted ISO image using the Redfish API.

14.3. PARTITIONING THE DISK

To run the full pre-caching process, you have to boot from a live ISO and use the factory-precaching-cli tool from a container image to partition and pre-cache all the artifacts required.

A live ISO or RHCOS live ISO is required because the disk must not be in use when the operating system (RHCOS) is written to the device during the provisioning. Single-disk servers can also be enabled with this procedure.

Prerequisites

- You have a disk that is not partitioned.
- You have access to the **quay.io/openshift-kni/telco-ran-tools:latest** image.
- You have enough storage to install OpenShift Container Platform and pre-cache the required images.

Procedure

1. Verify that the disk is cleared:

   ▪

```
# lsblk
```

Example output

```
NAME    MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
loop0     7:0    0  93.8G  0 loop /run/ephemeral
loop1     7:1    0 897.3M  1 loop /sysroot
sr0      11:0    1   999M  0 rom  /run/media/iso
nvme0n1 259:1    0   1.5T  0 disk
```

2. Erase any file system, RAID or partition table signatures from the device:

```
# wipefs -a /dev/nvme0n1
```

Example output

```
/dev/nvme0n1: 8 bytes were erased at offset 0x00000200 (gpt): 45 46 49 20 50 41 52 54
/dev/nvme0n1: 8 bytes were erased at offset 0x1749a955e00 (gpt): 45 46 49 20 50 41 52 54
/dev/nvme0n1: 2 bytes were erased at offset 0x000001fe (PMBR): 55 aa
```

IMPORTANT

The tool fails if the disk is not empty because it uses partition number 1 of the device for pre-caching the artifacts.

14.3.1. Creating the partition

Once the device is ready, you create a single partition and a GPT partition table. The partition is automatically labelled as **data** and created at the end of the device. Otherwise, the partition will be overridden by the **coreos-installer**.

IMPORTANT

The **coreos-installer** requires the partition to be created at the end of the device and to be labelled as **data**. Both requirements are necessary to save the partition when writing the RHCOS image to the disk.

Prerequisites

- The container must run as **privileged** due to formatting host devices.
- You have to mount the **/dev** folder so that the process can be executed inside the container.

Procedure

In the following example, the size of the partition is 250 GiB due to allow pre-caching the DU profile for Day 2 Operators.

1. Run the container as **privileged** and partition the disk:

```
# podman run -v /dev:/dev --privileged \
--rm quay.io/openshift-kni/telco-ran-tools:latest -- \
factory-precaching-cli partition \ 1
```

```
-d /dev/nvme0n1 \ 2
-s 250 3
```

1. Specifies the partitioning function of the factory-precaching-cli tool.
2. Defines the root directory on the disk.
3. Defines the size of the disk in GB.

2. Check the storage information:

```
# lsblk
```

Example output

```
NAME         MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
loop0          7:0    0  93.8G  0 loop /run/ephemeral
loop1          7:1    0 897.3M  1 loop /sysroot
sr0           11:0    1   999M  0 rom  /run/media/iso
nvme0n1      259:1    0   1.5T  0 disk
└─nvme0n1p1 259:3    0   250G  0 part
```

Verification

You must verify that the following requirements are met:

- The device has a GPT partition table
- The partition uses the latest sectors of the device.
- The partition is correctly labeled as **data**.

Query the disk status to verify that the disk is partitioned as expected:

```
# gdisk -l /dev/nvme0n1
```

Example output

```
GPT fdisk (gdisk) version 1.0.3

Partition table scan:
  MBR: protective
  BSD: not present
  APM: not present
  GPT: present

Found valid GPT with protective MBR; using GPT.
Disk /dev/nvme0n1: 3125627568 sectors, 1.5 TiB
Model: Dell Express Flash PM1725b 1.6TB SFF
Sector size (logical/physical): 512/512 bytes
Disk identifier (GUID): CB5A9D44-9B3C-4174-A5C1-C64957910B61
Partition table holds up to 128 entries
Main partition table begins at sector 2 and ends at sector 33
First usable sector is 34, last usable sector is 3125627534
```

```
Partitions will be aligned on 2048-sector boundaries
Total free space is 2601338846 sectors (1.2 TiB)

Number  Start (sector)    End (sector)  Size       Code  Name
   1      2601338880      3125627534   250.0 GiB   8300  data
```

14.3.2. Mounting the partition

After verifying that the disk is partitioned correctly, you can mount the device into **/mnt**.

IMPORTANT

It is recommended to mount the device into **/mnt** because that mounting point is used during GitOps ZTP preparation.

1. Verify that the partition is formatted as **xfs**:

   ```
   # lsblk -f /dev/nvme0n1
   ```

   Example output

   ```
   NAME        FSTYPE LABEL UUID                                 MOUNTPOINT
   nvme0n1
   └─nvme0n1p1 xfs          1bee8ea4-d6cf-4339-b690-a76594794071
   ```

2. Mount the partition:

   ```
   # mount /dev/nvme0n1p1 /mnt/
   ```

Verification

- Check that the partition is mounted:

  ```
  # lsblk
  ```

  Example output

  ```
  NAME        MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
  loop0         7:0    0  93.8G  0 loop /run/ephemeral
  loop1         7:1    0 897.3M  1 loop /sysroot
  sr0          11:0    1   999M  0 rom  /run/media/iso
  nvme0n1     259:1    0   1.5T  0 disk
  └─nvme0n1p1 259:2    0   250G  0 part /var/mnt 1
  ```

  1 The mount point is **/var/mnt** because the **/mnt** folder in RHCOS is a link to **/var/mnt**.

14.4. DOWNLOADING THE IMAGES

The factory-precaching-cli tool allows you to download the following images to your partitioned server:

- OpenShift Container Platform images
- Operator images that are included in the distributed unit (DU) profile for 5G RAN sites
- Operator images from disconnected registries

NOTE

The list of available Operator images can vary in different OpenShift Container Platform releases.

14.4.1. Downloading with parallel workers

The factory-precaching-cli tool uses parallel workers to download multiple images simultaneously. You can configure the number of workers with the **--parallel** or **-p** option. The default number is set to 80% of the available CPUs to the server.

NOTE

Your login shell may be restricted to a subset of CPUs, which reduces the CPUs available to the container. To remove this restriction, you can precede your commands with **taskset 0xffffffff**, for example:

```
# taskset 0xffffffff podman run --rm quay.io/openshift-kni/telco-ran-tools:latest factory-precaching-cli download --help
```

14.4.2. Preparing to download the OpenShift Container Platform images

To download OpenShift Container Platform container images, you need to know the multicluster engine version. When you use the **--du-profile** flag, you also need to specify the Red Hat Advanced Cluster Management (RHACM) version running in the hub cluster that is going to provision the single-node OpenShift.

Prerequisites

- You have RHACM and the multicluster engine Operator installed.
- You partitioned the storage device.
- You have enough space for the images on the partitioned device.
- You connected the bare-metal server to the Internet.
- You have a valid pull secret.

Procedure

1. Check the RHACM version and the multicluster engine version by running the following commands in the hub cluster:

```
$ oc get csv -A | grep -i advanced-cluster-management
```

Example output

```
open-cluster-management                    advanced-cluster-management.v2.6.3
Advanced Cluster Management for Kubernetes   2.6.3              advanced-cluster-
management.v2.6.3              Succeeded
```

```
$ oc get csv -A | grep -i multicluster-engine
```

Example output

```
multicluster-engine                        cluster-group-upgrades-operator.v0.0.3      cluster-
group-upgrades-operator            0.0.3                                               Pending
multicluster-engine                        multicluster-engine.v2.1.4              multicluster
engine for Kubernetes          2.1.4              multicluster-engine.v2.0.3
Succeeded
multicluster-engine                        openshift-gitops-operator.v1.5.7           Red Hat
OpenShift GitOps                  1.5.7              openshift-gitops-operator.v1.5.6-
0.1664915551.p   Succeeded
multicluster-engine                        openshift-pipelines-operator-rh.v1.6.4       Red Hat
OpenShift Pipelines                 1.6.4              openshift-pipelines-operator-rh.v1.6.3
Succeeded
```

2. To access the container registry, copy a valid pull secret on the server to be installed:

   a. Create the **.docker** folder:

   ```
   $ mkdir /root/.docker
   ```

   b. Copy the valid pull in the **config.json** file to the previously created **.docker/** folder:

   ```
   $ cp config.json /root/.docker/config.json (1)
   ```

   (1) **/root/.docker/config.json** is the default path where **podman** checks for the login credentials for the registry.

NOTE

If you use a different registry to pull the required artifacts, you need to copy the proper pull secret. If the local registry uses TLS, you need to include the certificates from the registry as well.

14.4.3. Downloading the OpenShift Container Platform images

The factory-precaching-cli tool allows you to pre-cache all the container images required to provision a specific OpenShift Container Platform release.

Procedure

- Pre-cache the release by running the following command:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker --privileged --rm quay.io/openshift-
kni/telco-ran-tools -- \
  factory-precaching-cli download \ (1)
  -r 4.16.0 \ (2)
```

```
--acm-version 2.6.3 \ (3)
--mce-version 2.1.4 \ (4)
-f /mnt \ (5)
--img quay.io/custom/repository (6)
```

1. Specifies the downloading function of the factory-precaching-cli tool.
2. Defines the OpenShift Container Platform release version.
3. Defines the RHACM version.
4. Defines the multicluster engine version.
5. Defines the folder where you want to download the images on the disk.
6. Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.

Example output

```
Generated /mnt/imageset.yaml
Generating list of pre-cached artifacts...
Processing artifact [1/176]: ocp-v4.0-art-
dev@sha256_6ac2b96bf4899c01a87366fd0feae9f57b1b61878e3b5823da0c3f34f707fbf5
Processing artifact [2/176]: ocp-v4.0-art-
dev@sha256_f48b68d5960ba903a0d018a10544ae08db5802e21c2fa5615a14fc58b1c1657c
Processing artifact [3/176]: ocp-v4.0-art-
dev@sha256_a480390e91b1c07e10091c3da2257180654f6b2a735a4ad4c3b69dbdb77bbc06

Processing artifact [4/176]: ocp-v4.0-art-
dev@sha256_ecc5d8dbd77e326dba6594ff8c2d091eefbc4d90c963a9a85b0b2f0e6155f995
Processing artifact [5/176]: ocp-v4.0-art-
dev@sha256_274b6d561558a2f54db08ea96df9892315bb773fc203b1dbcea418d20f4c7ad1
Processing artifact [6/176]: ocp-v4.0-art-
dev@sha256_e142bf5020f5ca0d1bdda0026bf97f89b72d21a97c9cc2dc71bf85050e822bbf
...
Processing artifact [175/176]: ocp-v4.0-art-
dev@sha256_16cd7eda26f0fb0fc965a589e1e96ff8577e560fcd14f06b5fda1643036ed6c8
Processing artifact [176/176]: ocp-v4.0-art-
dev@sha256_cf4d862b4a4170d4f611b39d06c31c97658e309724f9788e155999ae51e7188f
...
Summary:

Release:                            4.16.0
Hub Version:                        2.6.3
ACM Version:                        2.6.3
MCE Version:                        2.1.4
Include DU Profile:                 No
Workers:                            83
```

Verification

- Check that all the images are compressed in the target folder of server:

```
$ ls -l /mnt 1
```

1 It is recommended that you pre-cache the images in the **/mnt** folder.

Example output

```
-rw-r--r--. 1 root root  136352323 Oct 31 15:19 ocp-v4.0-art-
dev@sha256_edec37e7cd8b1611d0031d45e7958361c65e2005f145b471a8108f1b54316c07.t
gz
-rw-r--r--. 1 root root  156092894 Oct 31 15:33 ocp-v4.0-art-
dev@sha256_ee51b062b9c3c9f4fe77bd5b3cc9a3b12355d040119a1434425a824f137c61a9.tg
z
-rw-r--r--. 1 root root  172297800 Oct 31 15:29 ocp-v4.0-art-
dev@sha256_ef23d9057c367a36e4a5c4877d23ee097a731e1186ed28a26c8d21501cd82718.t
gz
-rw-r--r--. 1 root root  171539614 Oct 31 15:23 ocp-v4.0-art-
dev@sha256_f0497bb63ef6834a619d4208be9da459510df697596b891c0c633da144dbb025.t
gz
-rw-r--r--. 1 root root  160399150 Oct 31 15:20 ocp-v4.0-art-
dev@sha256_f0c339da117cde44c9aae8d0bd054bceb6f19fdb191928f6912a703182330ac2.tgz

-rw-r--r--. 1 root root  175962005 Oct 31 15:17 ocp-v4.0-art-
dev@sha256_f19dd2e80fb41ef31d62bb8c08b339c50d193fdb10fc39cc15b353cbbfeb9b24.tgz

-rw-r--r--. 1 root root  174942008 Oct 31 15:33 ocp-v4.0-art-
dev@sha256_f1dbb81fa1aa724e96dd2b296b855ff52a565fbef003d08030d63590ae6454df.tgz

-rw-r--r--. 1 root root  246693315 Oct 31 15:31 ocp-v4.0-art-
dev@sha256_f44dcf2c94e4fd843cbbf9b11128df2ba856cd813786e42e3da1fdfb0f6ddd01.tgz
-rw-r--r--. 1 root root  170148293 Oct 31 15:00 ocp-v4.0-art-
dev@sha256_f48b68d5960ba903a0d018a10544ae08db5802e21c2fa5615a14fc58b1c1657c.tg
z
-rw-r--r--. 1 root root  168899617 Oct 31 15:16 ocp-v4.0-art-
dev@sha256_f5099b0989120a8d08a963601214b5c5cb23417a707a8624b7eb52ab788a7f75.t
gz
-rw-r--r--. 1 root root  176592362 Oct 31 15:05 ocp-v4.0-art-
dev@sha256_f68c0e6f5e17b0b0f7ab2d4c39559ea89f900751e64b97cb42311a478338d9c3.tg
z
-rw-r--r--. 1 root root  157937478 Oct 31 15:37 ocp-v4.0-art-
dev@sha256_f7ba33a6a9db9cfc4b0ab0f368569e19b9fa08f4c01a0d5f6a243d61ab781bd8.tgz

-rw-r--r--. 1 root root  145535253 Oct 31 15:26 ocp-v4.0-art-
dev@sha256_f8f098911d670287826e9499806553f7a1dd3e2b5332abbec740008c36e84de5.t
gz
-rw-r--r--. 1 root root  158048761 Oct 31 15:40 ocp-v4.0-art-
dev@sha256_f914228ddbb99120986262168a705903a9f49724ffa958bb4bf12b2ec1d7fb47.tgz

-rw-r--r--. 1 root root  167914526 Oct 31 15:37 ocp-v4.0-art-
dev@sha256_fa3ca9401c7a9efda0502240aeb8d3ae2d239d38890454f17fe5158b62305010.tg
z
-rw-r--r--. 1 root root  164432422 Oct 31 15:24 ocp-v4.0-art-
dev@sha256_fc4783b446c70df30b3120685254b40ce13ba6a2b0bf8fb1645f116cf6a392f1.tgz
```

```
-rw-r--r--. 1 root root  306643814 Oct 31 15:11
troubleshoot@sha256_b86b8aea29a818a9c22944fd18243fa0347c7a2bf1ad8864113ff2bb2d8
e0726.tgz
```

14.4.4. Downloading the Operator images

You can also pre-cache Day-2 Operators used in the 5G Radio Access Network (RAN) Distributed Unit (DU) cluster configuration. The Day-2 Operators depend on the installed OpenShift Container Platform version.

IMPORTANT

You need to include the RHACM hub and multicluster engine Operator versions by using the **--acm-version** and **--mce-version** flags so the factory-precaching-cli tool can pre-cache the appropriate containers images for RHACM and the multicluster engine Operator.

Procedure

- Pre-cache the Operator images:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker --privileged --rm quay.io/openshift-
kni/telco-ran-tools:latest -- factory-precaching-cli download \ (1)
  -r 4.16.0 \ (2)
  --acm-version 2.6.3 \ (3)
  --mce-version 2.1.4 \ (4)
  -f /mnt \ (5)
  --img quay.io/custom/repository (6)
  --du-profile -s (7)
```

(1) Specifies the downloading function of the factory-precaching-cli tool.

(2) Defines the OpenShift Container Platform release version.

(3) Defines the RHACM version.

(4) Defines the multicluster engine version.

(5) Defines the folder where you want to download the images on the disk.

(6) Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.

(7) Specifies pre-caching the Operators included in the DU configuration.

Example output

```
Generated /mnt/imageset.yaml
Generating list of pre-cached artifacts...
Processing artifact [1/379]: ocp-v4.0-art-
dev@sha256_7753a8d9dd5974be8c90649aadd7c914a3d8a1f1e016774c7ac7c9422e9f9958
Processing artifact [2/379]: ose-kube-rbac-
proxy@sha256_c27a7c01e5968aff16b6bb6670423f992d1a1de1a16e7e260d12908d3322431c
```

```
Processing artifact [3/379]: ocp-v4.0-art-
dev@sha256_370e47a14c798ca3f8707a38b28cfc28114f492bb35fe1112e55d1eb51022c99
...
Processing artifact [378/379]: ose-local-storage-
operator@sha256_0c81c2b79f79307305e51ce9d3837657cf9ba5866194e464b4d1b299f85034
d0
Processing artifact [379/379]: multicluster-operators-channel-
rhel8@sha256_c10f6bbb84fe36e05816e873a72188018856ad6aac6cc16271a1b3966f73ceb3

...
Summary:

Release:                    4.16.0
Hub Version:                  2.6.3
ACM Version:                   2.6.3
MCE Version:                   2.1.4
Include DU Profile:             Yes
Workers:                    83
```

14.4.5. Pre-caching custom images in disconnected environments

The **--generate-imageset** argument stops the factory-precaching-cli tool after the **ImageSetConfiguration** custom resource (CR) is generated. This allows you to customize the **ImageSetConfiguration** CR before downloading any images. After you customized the CR, you can use the **--skip-imageset** argument to download the images that you specified in the **ImageSetConfiguration** CR.

You can customize the **ImageSetConfiguration** CR in the following ways:

- Add Operators and additional images
- Remove Operators and additional images
- Change Operator and catalog sources to local or disconnected registries

Procedure

1. Pre-cache the images:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker --privileged --rm quay.io/openshift-
kni/telco-ran-tools:latest -- factory-precaching-cli download \ 1
  -r 4.16.0 \ 2
  --acm-version 2.6.3 \ 3
  --mce-version 2.1.4 \ 4
  -f /mnt \ 5
  --img quay.io/custom/repository 6
  --du-profile -s \ 7
  --generate-imageset 8
```

1 Specifies the downloading function of the factory-precaching-cli tool.

2 Defines the OpenShift Container Platform release version.

3 Defines the RHACM version.

4 Defines the multicluster engine version.

5 Defines the folder where you want to download the images on the disk.

6 Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.

7 Specifies pre-caching the Operators included in the DU configuration.

8 The **--generate-imageset** argument generates the **ImageSetConfiguration** CR only, which allows you to customize the CR.

Example output

```
Generated /mnt/imageset.yaml
```

Example ImageSetConfiguration CR

```
apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
mirror:
  platform:
    channels:
    - name: stable-4.16
      minVersion: 4.16.0 (1)
      maxVersion: 4.16.0
  additionalImages:
    - name: quay.io/custom/repository
  operators:
    - catalog: registry.redhat.io/redhat/redhat-operator-index:v4.16
      packages:
        - name: advanced-cluster-management (2)
          channels:
             - name: 'release-2.6'
               minVersion: 2.6.3
               maxVersion: 2.6.3
        - name: multicluster-engine (3)
          channels:
             - name: 'stable-2.1'
               minVersion: 2.1.4
               maxVersion: 2.1.4
        - name: local-storage-operator (4)
          channels:
            - name: 'stable'
        - name: ptp-operator (5)
          channels:
            - name: 'stable'
        - name: sriov-network-operator (6)
          channels:
            - name: 'stable'
        - name: cluster-logging (7)
          channels:
```

```
          - name: 'stable'
        - name: lvms-operator (8)
          channels:
          - name: 'stable-4.16'
        - name: amq7-interconnect-operator (9)
          channels:
          - name: '1.10.x'
        - name: bare-metal-event-relay (10)
          channels:
          - name: 'stable'
      - catalog: registry.redhat.io/redhat/certified-operator-index:v4.16
        packages:
        - name: sriov-fec (11)
          channels:
          - name: 'stable'
```

1. The platform versions match the versions passed to the tool.

2, 3. The versions of RHACM and the multicluster engine Operator match the versions passed to the tool.

4, 5, 6, 7, 8, 9, 10, 11. The CR contains all the specified DU Operators.

2. Customize the catalog resource in the CR:

```
apiVersion: mirror.openshift.io/v1alpha2
kind: ImageSetConfiguration
mirror:
  platform:
[...]
  operators:
    - catalog: eko4.cloud.lab.eng.bos.redhat.com:8443/redhat/certified-operator-index:v4.16
      packages:
        - name: sriov-fec
          channels:
            - name: 'stable'
```

When you download images by using a local or disconnected registry, you have to first add certificates for the registries that you want to pull the content from.

3. To avoid any errors, copy the registry certificate into your server:

```
# cp /tmp/eko4-ca.crt /etc/pki/ca-trust/source/anchors/.
```

4. Then, update the certificates trust store:

```
# update-ca-trust
```

5. Mount the host **/etc/pki** folder into the factory-cli image:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker -v /etc/pki:/etc/pki --privileged --rm
quay.io/openshift-kni/telco-ran-tools:latest -- \
factory-precaching-cli download \ (1)
```

```
-r 4.16.0 \ 2
--acm-version 2.6.3 \ 3
--mce-version 2.1.4 \ 4
-f /mnt \ 5
--img quay.io/custom/repository 6
--du-profile -s \ 7
--skip-imageset 8
```

1. Specifies the downloading function of the factory-precaching-cli tool.
2. Defines the OpenShift Container Platform release version.
3. Defines the RHACM version.
4. Defines the multicluster engine version.
5. Defines the folder where you want to download the images on the disk.
6. Optional. Defines the repository where you store your additional images. These images are downloaded and pre-cached on the disk.
7. Specifies pre-caching the Operators included in the DU configuration.
8. The **--skip-imageset** argument allows you to download the images that you specified in your customized **ImageSetConfiguration** CR.

6. Download the images without generating a new **imageSetConfiguration** CR:

```
# podman run -v /mnt:/mnt -v /root/.docker:/root/.docker --privileged --rm quay.io/openshift-
kni/telco-ran-tools:latest -- factory-precaching-cli download -r 4.16.0 \
--acm-version 2.6.3 --mce-version 2.1.4 -f /mnt \
--img quay.io/custom/repository \
--du-profile -s \
--skip-imageset
```

Additional resources

- To access the online Red Hat registries, see OpenShift installation customization tools.
- For more information about using the multicluster engine, see About cluster lifecycle with the multicluster engine operator.

14.5. PRE-CACHING IMAGES IN GITOPS ZTP

The **SiteConfig** manifest defines how an OpenShift cluster is to be installed and configured. In the GitOps Zero Touch Provisioning (ZTP) provisioning workflow, the factory-precaching-cli tool requires the following additional fields in the **SiteConfig** manifest:

- **clusters.ignitionConfigOverride**
- **nodes.installerArgs**
- **nodes.ignitionConfigOverride**

Example SiteConfig with additional fields

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
metadata:
  name: "example-5g-lab"
  namespace: "example-5g-lab"
spec:
  baseDomain: "example.domain.redhat.com"
  pullSecretRef:
    name: "assisted-deployment-pull-secret"
  clusterImageSetNameRef: "img4.9.10-x86-64-appsub" 1
  sshPublicKey: "ssh-rsa ..."
  clusters:
  - clusterName: "sno-worker-0"
    clusterImageSetNameRef: "eko4-img4.11.5-x86-64-appsub" 2
    clusterLabels:
      group-du-sno: ""
      common-411: true
      sites : "example-5g-lab"
      vendor: "OpenShift"
    clusterNetwork:
      - cidr: 10.128.0.0/14
        hostPrefix: 23
    machineNetwork:
      - cidr: 10.19.32.192/26
    serviceNetwork:
      - 172.30.0.0/16
    networkType: "OVNKubernetes"
    additionalNTPSources:
      - clock.corp.redhat.com
    ignitionConfigOverride:
      '{
        "ignition": {
          "version": "3.1.0"
        },
        "systemd": {
          "units": [
            {
              "name": "var-mnt.mount",
              "enabled": true,
              "contents": "[Unit]\nDescription=Mount partition with artifacts\nBefore=precache-
images.service\nBindsTo=precache-
images.service\nStopWhenUnneeded=true\n\n[Mount]\nWhat=/dev/disk/by-
partlabel/data\nWhere=/var/mnt\nType=xfs\nTimeoutSec=30\n\n[Install]\nRequiredBy=precache-
images.service"
            },
            {
              "name": "precache-images.service",
              "enabled": true,
              "contents": "[Unit]\nDescription=Extracts the precached images in discovery
stage\nAfter=var-
mnt.mount\nBefore=agent.service\n\n[Service]\nType=oneshot\nUser=root\nWorkingDirectory=/var/mnt\
nExecStart=bash /usr/local/bin/extract-ai.sh\n#TimeoutStopSec=30\n\n[Install]\nWantedBy=multi-
user.target default.target\nWantedBy=agent.service"
```

```
          }
        ]
      },
      "storage": {
        "files": [
          {
            "overwrite": true,
            "path": "/usr/local/bin/extract-ai.sh",
            "mode": 755,
            "user": {
              "name": "root"
            },
            "contents": {
              "source":
"data:,%23%21%2Fbin%2Fbash%0A%0AFOLDER%3D%22%24%7BFOLDER%3A-
%24%28pwd%29%7D%22%0AOCP_RELEASE_LIST%3D%22%24%7BOCP_RELEASE_LIST%3A-
ai-
images.txt%7D%22%0ABINARY_FOLDER%3D%2Fvar%2Fmnt%0A%0Apushd%20%24FOLDER%0
A%0Atotal_copies%3D%24%28sort%20-
u%20%24BINARY_FOLDER%2F%24OCP_RELEASE_LIST%20%7C%20wc%20-
l%29%20%20%23%20Required%20to%20keep%20track%20of%20the%20pull%20task%20vs%20tot
al%0Acurrent_copy%3D1%0A%0Awhile%20read%20-
r%20line%3B%0Ado%0A%20%20uri%3D%24%28echo%20%22%24line%22%20%7C%20awk%20%
27%7Bprint%241%7D%27%29%0A%20%20%23tar%3D%24%28echo%20%22%24line%22%20%7
C%20awk%20%27%7Bprint%242%7D%27%29%0A%20%20podman%20image%20exists%20%24ur
i%0A%20%20if%20%5B%5B%20%24%3F%20-
eq%200%20%5D%5D%3B%20then%0A%20%20%20%20%20%20echo%20%22Skipping%20existin
g%20image%20%24tar%22%0A%20%20%20%20%20%20echo%20%22Copying%20%24%7Buri%7
D%20%5B%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20%20%20
%20%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29%0A%20%20%20%20
%20%20continue%0A%20%20fi%0A%20%20tar%3D%24%28echo%20%22%24uri%22%20%7C%2
0%20rev%20%7C%20cut%20-d%20%22%2F%22%20-
f1%20%7C%20rev%20%7C%20tr%20%22%3A%22%20%22_%22%29%0A%20%20tar%20zxvf%20
%24%7Btar%7D.tgz%0A%20%20if%20%5B%20%24%3F%20-
eq%200%20%5D%3B%20then%20rm%20-
f%20%24%7Btar%7D.gz%3B%20fi%0A%20%20echo%20%22Copying%20%24%7Buri%7D%20%5B
%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20skopeo%20copy%20
dir%3A%2F%2F%24%28pwd%29%2F%24%7Btar%7D%20containers-
storage%3A%24%7Buri%7D%0A%20%20if%20%5B%20%24%3F%20-
eq%200%20%5D%3B%20then%20rm%20-
rf%20%24%7Btar%7D%3B%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29
%3B%20fi%0Adone%20%3C%20%24%7BBINARY_FOLDER%7D%2F%24%7BOCP_RELEASE_LI
ST%7D%0A%0A%23%20workaround%20while%20https%3A%2F%2Fgithub.com%2Fopenshift%2Fa
ssisted-service%2Fpull%2F3546%0A%23cp%20%2Fvar%2Fmnt%2Fmodified-rhcos-4.10.3-x86_64-
metal.x86_64.raw.gz%20%2Fvar%2Ftmp%2F.%0A%0Aexit%200"
            }
          },
          {
            "overwrite": true,
            "path": "/usr/local/bin/agent-fix-bz1964591",
            "mode": 755,
            "user": {
              "name": "root"
            },
            "contents": {
              "source":
```

```
"data:,%23%21%2Fusr%2Fbin%2Fsh%0A%0A%23%20This%20script%20is%20a%20workaround%2
0for%20bugzilla%201964591%20where%20symlinks%20inside%20%2Fvar%2Flib%2Fcontainers%2F
%20get%0A%23%20corrupted%20under%20some%20circumstances.%0A%23%0A%23%20In%20or
der%20to%20let%20agent.service%20start%20correctly%20we%20are%20checking%20here%20whe
ther%20the%20requested%0A%23%20container%20image%20exists%20and%20in%20case%20%2
2podman%20images%22%20returns%20an%20error%20we%20try%20removing%20the%20faulty%
0A%23%20image.%0A%23%0A%23%20In%20such%20a%20scenario%20agent.service%20will%20d
etect%20the%20image%20is%20not%20present%20and%20pull%20it%20again.%20In%20case%0A
%23%20the%20image%20is%20present%20and%20can%20be%20detected%20correctly%2C%20no
%20any%20action%20is%20required.%0A%0AIMAGE%3D%24%28echo%20%241%20%7C%20sed
%20%27s%2F%3A.%2A%2F%2F%27%29%0Apodman%20image%20exists%20%24IMAGE%20%7
C%7C%20echo%20%22already%20loaded%22%20%7C%7C%20echo%20%22need%20to%20be%
20pulled%22%0A%23podman%20images%20%7C%20grep%20%24IMAGE%20%7C%7C%20podm
an%20rmi%20--force%20%241%20%7C%7C%20true"
              }
            }
          ]
        }
      }'
    nodes:
      - hostName: "snonode.sno-worker-0.example.domain.redhat.com"
        role: "master"
        bmcAddress: "idrac-virtualmedia+https://10.19.28.53/redfish/v1/Systems/System.Embedded.1"
        bmcCredentialsName:
          name: "worker0-bmh-secret"
        bootMACAddress: "e4:43:4b:bd:90:46"
        bootMode: "UEFI"
        rootDeviceHints:
          deviceName: /dev/disk/by-path/pci-0000:01:00.0-scsi-0:2:0:0
        installerArgs: '["--save-partlabel", "data"]'
        ignitionConfigOverride: |
           {
            "ignition": {
              "version": "3.1.0"
            },
            "systemd": {
              "units": [
                {
                  "name": "var-mnt.mount",
                  "enabled": true,
                  "contents": "[Unit]\nDescription=Mount partition with artifacts\nBefore=precache-ocp-
images.service\nBindsTo=precache-ocp-
images.service\nStopWhenUnneeded=true\n\n[Mount]\nWhat=/dev/disk/by-
partlabel/data\nWhere=/var/mnt\nType=xfs\nTimeoutSec=30\n\n[Install]\nRequiredBy=precache-ocp-
images.service"
                },
                {
                  "name": "precache-ocp-images.service",
                  "enabled": true,
                  "contents": "[Unit]\nDescription=Extracts the precached OCP images into containers
storage\nAfter=var-mnt.mount\nBefore=machine-config-daemon-pull.service nodeip-
configuration.service\n\n[Service]\nType=oneshot\nUser=root\nWorkingDirectory=/var/mnt\nExecStart=b
ash /usr/local/bin/extract-ocp.sh\nTimeoutStopSec=60\n\n[Install]\nWantedBy=multi-user.target"
                }
              ]
            },
            "storage": {
              "files": [
                {
                  "overwrite": true,
                  "path": "/usr/local/bin/extract-ocp.sh",
                  "mode": 755,
                  "user": {
                    "name": "root"
                  },
                  "contents": {
                    "source":
"data:,%23%21%2Fbin%2Fbash%0A%0AFOLDER%3D%22%24%7BFOLDER%3A-
%24%28pwd%29%7D%22%0AOCP_RELEASE_LIST%3D%22%24%7BOCP_RELEASE_LIST%3A-
ocp-
images.txt%7D%22%0ABINARY_FOLDER%3D%2Fvar%2Fmnt%0A%0Apushd%20%24FOLDER%0
A%0Atotal_copies%3D%24%28sort%20-
u%20%24BINARY_FOLDER%2F%24OCP_RELEASE_LIST%20%7C%20wc%20-
l%29%20%20%23%20Required%20to%20keep%20track%20of%20the%20pull%20task%20vs%20tot
al%0Acurrent_copy%3D1%0A%0Awhile%20read%20-
r%20line%3B%0Ado%0A%20%20uri%3D%24%28echo%20%22%24line%22%20%7C%20awk%20%
27%7Bprint%241%7D%27%29%0A%20%20%23tar%3D%24%28echo%20%22%24line%22%20%7
C%20awk%20%27%7Bprint%242%7D%27%29%0A%20%20podman%20image%20exists%20%24ur
i%0A%20%20if%20%5B%5B%20%24%3F%20-
eq%200%20%5D%5D%3B%20then%0A%20%20%20%20%20%20echo%20%22Skipping%20existin
g%20image%20%24tar%22%0A%20%20%20%20%20%20echo%20%22Copying%20%24%7Buri%7
D%20%5B%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20%20%20
%20%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29%0A%20%20%20%20
%20%20continue%0A%20%20fi%0A%20%20tar%3D%24%28echo%20%22%24uri%22%20%7C%2
0%20rev%20%7C%20cut%20-d%20%22%2F%22%20-
f1%20%7C%20rev%20%7C%20tr%20%22%3A%22%20%22_%22%29%0A%20%20tar%20zxvf%20
%24%7Btar%7D.tgz%0A%20%20if%20%5B%20%24%3F%20-
eq%200%20%5D%3B%20then%20rm%20-
f%20%24%7Btar%7D.gz%3B%20fi%0A%20%20echo%20%22Copying%20%24%7Buri%7D%20%5B
%24%7Bcurrent_copy%7D%2F%24%7Btotal_copies%7D%5D%22%0A%20%20skopeo%20copy%20
dir%3A%2F%2F%24%28pwd%29%2F%24%7Btar%7D%20containers-
storage%3A%24%7Buri%7D%0A%20%20if%20%5B%20%24%3F%20-
eq%200%20%5D%3B%20then%20rm%20-
rf%20%24%7Btar%7D%3B%20current_copy%3D%24%28%28current_copy%20%2B%201%29%29
%3B%20fi%0Adone%20%3C%20%24%7BBINARY_FOLDER%7D%2F%24%7BOCP_RELEASE_LI
ST%7D%0A%0Aexit%200"
                  }
                }
              ]
            }
          }
        nodeNetwork:
          config:
            interfaces:
              - name: ens1f0
                type: ethernet
                state: up
                macAddress: "AA:BB:CC:11:22:33"
                ipv4:
                  enabled: true
                  dhcp: true
                ipv6:
```

```
          enabled: false
      interfaces:
        - name: "ens1f0"
          macAddress: "AA:BB:CC:11:22:33"
```

1. Specifies the cluster image set used for deployment, unless you specify a different image set in the **spec.clusters.clusterImageSetNameRef** field.

2. Specifies the cluster image set used to deploy an individual cluster. If defined, it overrides the **spec.clusterImageSetNameRef** at the site level.

14.5.1. Understanding the clusters.ignitionConfigOverride field

The **clusters.ignitionConfigOverride** field adds a configuration in Ignition format during the GitOps ZTP discovery stage. The configuration includes **systemd** services in the ISO mounted in virtual media. This way, the scripts are part of the discovery RHCOS live ISO and they can be used to load the Assisted Installer (AI) images.

systemd services

The **systemd** services are **var-mnt.mount** and **precache-images.services**. The **precache-images.service** depends on the disk partition to be mounted in **/var/mnt** by the **var-mnt.mount** unit. The service calls a script called **extract-ai.sh**.

extract-ai.sh

The **extract-ai.sh** script extracts and loads the required images from the disk partition to the local container storage. When the script finishes successfully, you can use the images locally.

agent-fix-bz1964591

The **agent-fix-bz1964591** script is a workaround for an AI issue. To prevent AI from removing the images, which can force the **agent.service** to pull the images again from the registry, the **agent-fix-bz1964591** script checks if the requested container images exist.

14.5.2. Understanding the nodes.installerArgs field

The **nodes.installerArgs** field allows you to configure how the **coreos-installer** utility writes the RHCOS live ISO to disk. You need to indicate to save the disk partition labeled as **data** because the artifacts saved in the **data** partition are needed during the OpenShift Container Platform installation stage.

The extra parameters are passed directly to the **coreos-installer** utility that writes the live RHCOS to disk. On the next reboot, the operating system starts from the disk.

You can pass several options to the **coreos-installer** utility:

```
OPTIONS:
...
   -u, --image-url <URL>
           Manually specify the image URL

   -f, --image-file <path>
           Manually specify a local image file

   -i, --ignition-file <path>
           Embed an Ignition config from a file
```

```
    -I, --ignition-url <URL>
            Embed an Ignition config from a URL
...
        --save-partlabel <lx>...
            Save partitions with this label glob

        --save-partindex <id>...
            Save partitions with this number or range
...
        --insecure-ignition
            Allow Ignition URL without HTTPS or hash
```

14.5.3. Understanding the nodes.ignitionConfigOverride field

Similarly to **clusters.ignitionConfigOverride**, the **nodes.ignitionConfigOverride** field allows the addtion of configurations in Ignition format to the **coreos-installer** utility, but at the OpenShift Container Platform installation stage. When the RHCOS is written to disk, the extra configuration included in the GitOps ZTP discovery ISO is no longer available. During the discovery stage, the extra configuration is stored in the memory of the live OS.

NOTE

At this stage, the number of container images extracted and loaded is bigger than in the discovery stage. Depending on the OpenShift Container Platform release and whether you install the Day-2 Operators, the installation time can vary.

At the installation stage, the **var-mnt.mount** and **precache-ocp.services systemd** services are used.

precache-ocp.service

The **precache-ocp.service** depends on the disk partition to be mounted in **/var/mnt** by the **var-mnt.mount** unit. The **precache-ocp.service** service calls a script called **extract-ocp.sh**.

IMPORTANT

To extract all the images before the OpenShift Container Platform installation, you must execute **precache-ocp.service** before executing the **machine-config-daemon-pull.service** and **nodeip-configuration.service** services.

extract-ocp.sh

The **extract-ocp.sh** script extracts and loads the required images from the disk partition to the local container storage.

When you commit the **SiteConfig** and optional **PolicyGenerator** or **PolicyGenTemplate** custom resources (CRs) to the Git repo that Argo CD is monitoring, you can start the GitOps ZTP workflow by syncing the CRs with the hub cluster.

14.6. TROUBLESHOOTING A "RENDERED CATALOG IS INVALID" ERROR

When you download images by using a local or disconnected registry, you might see the **The rendered catalog is invalid** error. This means that you are missing certificates of the new registry you want to pull content from.

NOTE

The factory-precaching-cli tool image is built on a UBI RHEL image. Certificate paths and locations are the same on RHCOS.

Example error

```
Generating list of pre-cached artifacts...
error: unable to run command oc-mirror -c /mnt/imageset.yaml file:///tmp/fp-cli-3218002584/mirror --
ignore-history --dry-run: Creating directory: /tmp/fp-cli-3218002584/mirror/oc-mirror-
workspace/src/publish
Creating directory: /tmp/fp-cli-3218002584/mirror/oc-mirror-workspace/src/v2
Creating directory: /tmp/fp-cli-3218002584/mirror/oc-mirror-workspace/src/charts
Creating directory: /tmp/fp-cli-3218002584/mirror/oc-mirror-workspace/src/release-signatures
backend is not configured in /mnt/imageset.yaml, using stateless mode
backend is not configured in /mnt/imageset.yaml, using stateless mode
No metadata detected, creating new workspace
level=info msg=trying next host error=failed to do request: Head
"https://eko4.cloud.lab.eng.bos.redhat.com:8443/v2/redhat/redhat-operator-index/manifests/v4.11":
x509: certificate signed by unknown authority host=eko4.cloud.lab.eng.bos.redhat.com:8443

The rendered catalog is invalid.

Run "oc-mirror list operators --catalog CATALOG-NAME --package PACKAGE-NAME" for more
information.

error: error rendering new refs: render reference
"eko4.cloud.lab.eng.bos.redhat.com:8443/redhat/redhat-operator-index:v4.11": error resolving name :
failed to do request: Head "https://eko4.cloud.lab.eng.bos.redhat.com:8443/v2/redhat/redhat-
operator-index/manifests/v4.11": x509: certificate signed by unknown authority
```

Procedure

1. Copy the registry certificate into your server:

   ```
   # cp /tmp/eko4-ca.crt /etc/pki/ca-trust/source/anchors/.
   ```

2. Update the certificates truststore:

   ```
   # update-ca-trust
   ```

3. Mount the host **/etc/pki** folder into the factory-cli image:

   ```
   # podman run -v /mnt:/mnt -v /root/.docker:/root/.docker -v /etc/pki:/etc/pki --privileged -it --rm
   quay.io/openshift-kni/telco-ran-tools:latest -- \
   factory-precaching-cli download -r 4.16.0 --acm-version 2.5.4 \
      --mce-version 2.0.4 -f /mnt \--img quay.io/custom/repository
      --du-profile -s --skip-imageset
   ```

CHAPTER 15. IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS

15.1. UNDERSTANDING THE IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS

From OpenShift Container Platform 4.14.13, the Lifecycle Agent provides you with an alternative way to upgrade the platform version of a single-node OpenShift cluster. The image-based upgrade is faster than the standard upgrade method and allows you to directly upgrade from OpenShift Container Platform <4.y> to <4.y+2>, and <4.y.z> to <4.y.z+n>.

This upgrade method utilizes a generated OCI image from a dedicated seed cluster that is installed on the target single-node OpenShift cluster as a new **ostree** stateroot. A seed cluster is a single-node OpenShift cluster deployed with the target OpenShift Container Platform version, Day 2 Operators, and configurations that are common to all target clusters.

You can use the seed image, which is generated from the seed cluster, to upgrade the platform version on any single-node OpenShift cluster that has the same combination of hardware, Day 2 Operators, and cluster configuration as the seed cluster.

IMPORTANT

The image-based upgrade uses custom images that are specific to the hardware platform that the clusters are running on. Each different hardware platform requires a separate seed image.

The Lifecycle Agent uses two custom resources (CRs) on the participating clusters to orchestrate the upgrade:

- On the seed cluster, the **SeedGenerator** CR allows for the seed image generation. This CR specifies the repository to push the seed image to.
- On the target cluster, the **ImageBasedUpgrade** CR specifies the seed image for the upgrade of the target cluster and the backup configurations for your workloads.

Example SeedGenerator CR

```
apiVersion: lca.openshift.io/v1
kind: SeedGenerator
metadata:
  name: seedimage
spec:
  seedImage: <seed_image>
```

Example ImageBasedUpgrade CR

```
apiVersion: lca.openshift.io/v1
kind: ImageBasedUpgrade
metadata:
  name: upgrade
spec:
  stage: Idle 1
  seedImageRef: 2
    version: <target_version>
    image: <seed_container_image>
    pullSecretRef:
      name: <seed_pull_secret>
  autoRollbackOnFailure: {}
#    initMonitorTimeoutSeconds: 1800 3
  extraManifests: 4
  - name: example-extra-manifests
    namespace: openshift-lifecycle-agent
  oadpContent: 5
  - name: oadp-cm-example
    namespace: openshift-adp
```

1. Defines the desired stage for the **ImageBasedUpgrade** CR. The value can be **Idle**, **Prep**, **Upgrade**, or **Rollback**.

2. Defines the target platform version, the seed image to be used, and the secret required to access the image.

3. (Optional) Specify the time frame in seconds to roll back when the upgrade does not complete within that time frame after the first reboot. If not defined or set to **0**, the default value of **1800** seconds (30 minutes) is used.

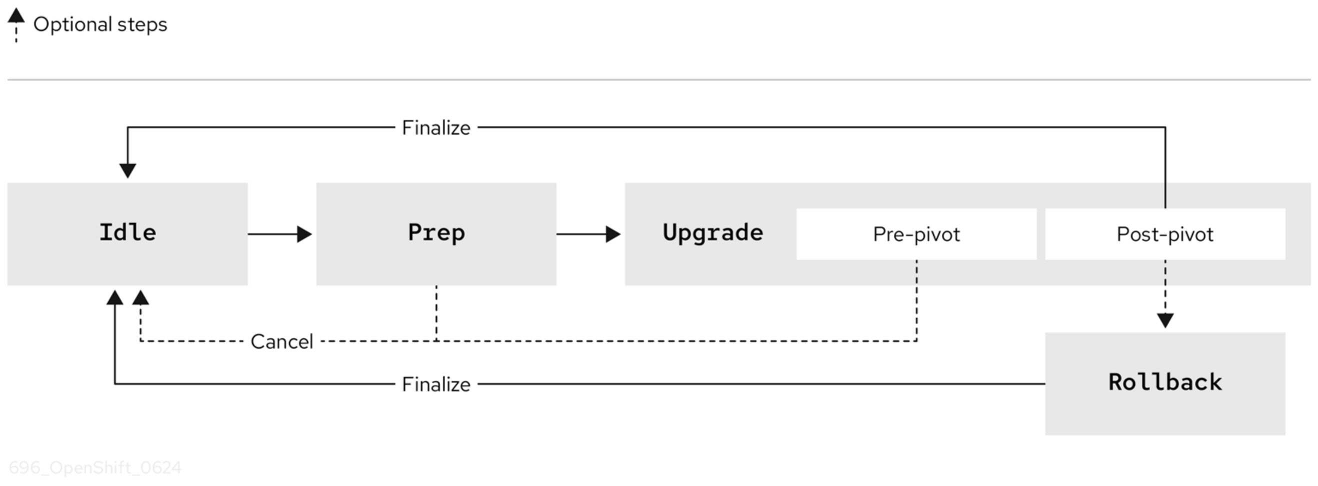
4. (Optional) Specify the list of **ConfigMap** resources that contain your custom catalog sources to retain after the upgrade, and your extra manifests to apply to the target cluster that are not part of the seed image.

5. Specify the list of **ConfigMap** resources that contain the OADP **Backup** and **Restore** CRs.

15.1.1. Stages of the image-based upgrade

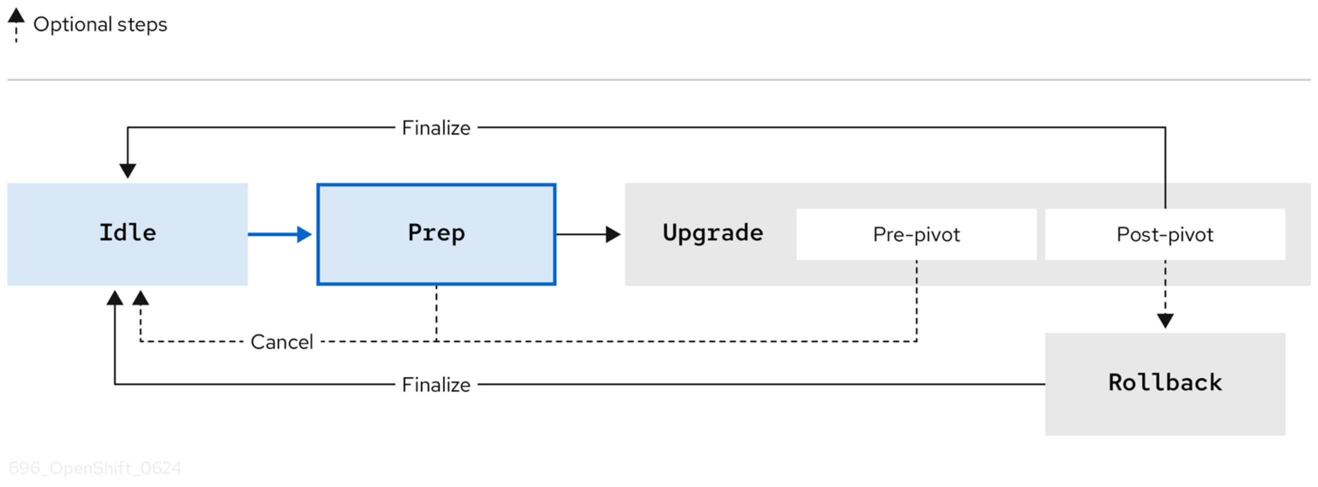
After generating the seed image on the seed cluster, you can move through the stages on the target cluster by setting the **spec.stage** field to one of the following values in the **ImageBasedUpgrade** CR:

- **Idle**
- **Prep**
- **Upgrade**
- **Rollback** (Optional)



15.1.1.1. Idle stage

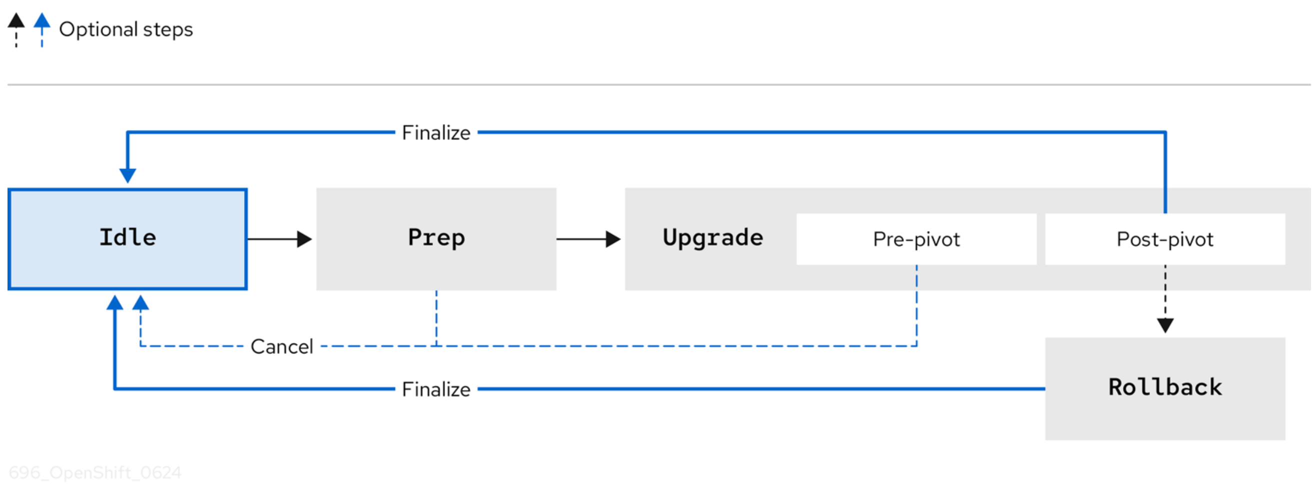
The Lifecycle Agent creates an **ImageBasedUpgrade** CR set to **stage: Idle** when the Operator is first deployed. This is the default stage. There is no ongoing upgrade and the cluster is ready to move to the **Prep** stage.



You also move to the **Idle** stage to do one of the following steps:

- Finalize a successful upgrade
- Finalize a rollback
- Cancel an ongoing upgrade until the pre-pivot phase in the **Upgrade** stage

Moving to the **Idle** stage ensures that the Lifecycle Agent cleans up resources, so that the cluster is ready for upgrades again.



IMPORTANT

If using RHACM when you cancel an upgrade, you must remove the **import.open-cluster-management.io/disable-auto-import** annotation from the target managed cluster to re-enable the automatic import of the cluster.

15.1.1.2. Prep stage

NOTE

You can complete this stage before a scheduled maintenance window.

For the **Prep** stage, you specify the following upgrade details in the **ImageBasedUpgrade** CR:

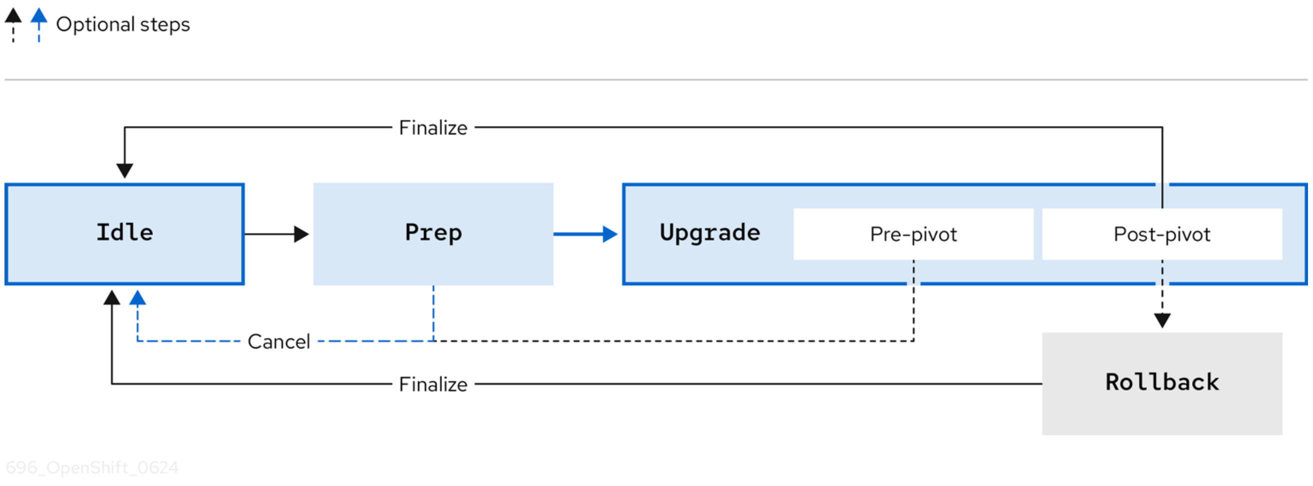
- seed image to use
- resources to back up
- extra manifests to apply and custom catalog sources to retain after the upgrade, if any

Then, based on what you specify, the Lifecycle Agent prepares for the upgrade without impacting the current running version. During this stage, the Lifecycle Agent ensures that the target cluster is ready to proceed to the **Upgrade** stage by checking if it meets certain conditions and pulls the seed image to the target cluster with additional container images specified in the seed image.

You also prepare backup resources with the OADP Operator's **Backup** and **Restore** CRs. These CRs are used in the **Upgrade** stage to reconfigure the cluster, register the cluster with RHACM, and restore application artifacts.

In addition to the OADP Operator, the Lifecycle Agent uses the **ostree** versioning system to create a backup, which allows complete cluster reconfiguration after both upgrade and rollback.

After the **Prep** stage finishes, you can cancel the upgrade process by moving to the **Idle** stage or you can start the upgrade by moving to the **Upgrade** stage in the **ImageBasedUpgrade** CR. If you cancel the upgrade, the Operator performs cleanup operations.



15.1.1.3. Upgrade stage

The **Upgrade** stage consists of two phases:

pre-pivot

Just before pivoting to the new stateroot, the Lifecycle Agent collects the required cluster specific artifacts and stores them in the new stateroot. The backup of your cluster resources specified in the **Prep** stage are created on a compatible Object storage solution. The Lifecycle Agent exports CRs specified in the **extraManifests** field in the **ImageBasedUpgrade** CR or the CRs described in the ZTP policies that are bound to the target cluster. After pre-pivot phase has completed, the Lifecycle Agent sets the new stateroot deployment as the default boot entry and reboots the node.

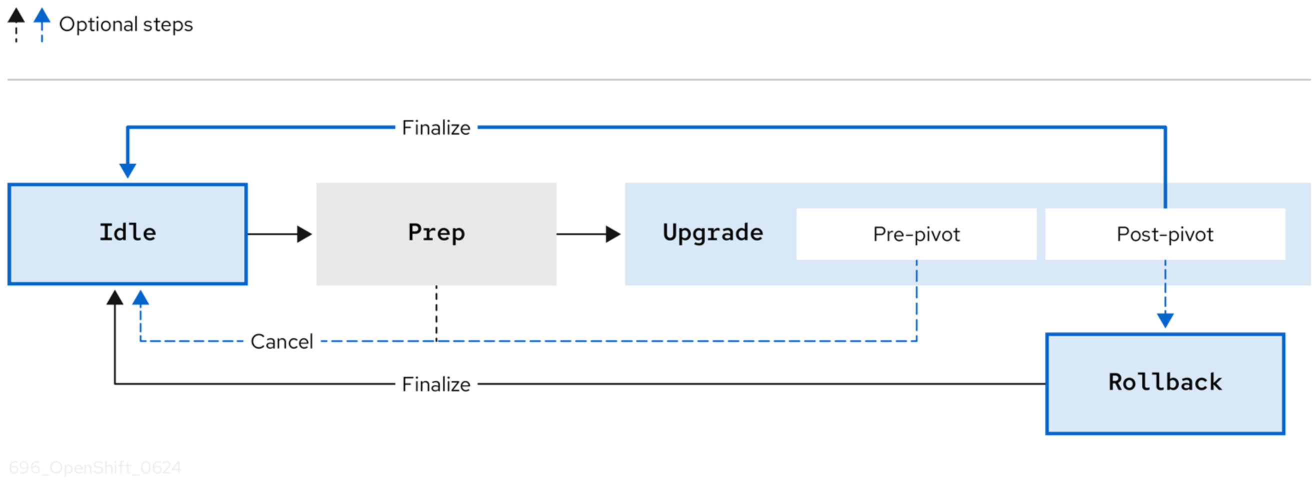
post-pivot

After booting from the new stateroot, the Lifecycle Agent reconfigures the cluster by applying cluster-specific artifacts that were collected in the pre-pivot phase. The Operator applies all saved CRs, and restores the backups. The Operator also regenerates the seed image's cluster cryptography. This ensures that each single-node OpenShift cluster upgraded with the same seed image has unique and valid cryptographic objects.

After the upgrade has completed and you are satisfied with the changes, you can finalize the upgrade by moving to the **Idle** stage.

IMPORTANT

When you finalize the upgrade, you cannot roll back to the original release.



If you want to cancel the upgrade, you can do so until the pre-pivot phase of the **Upgrade** stage. If you encounter issues after the upgrade, you can move to the **Rollback** stage for a manual rollback.

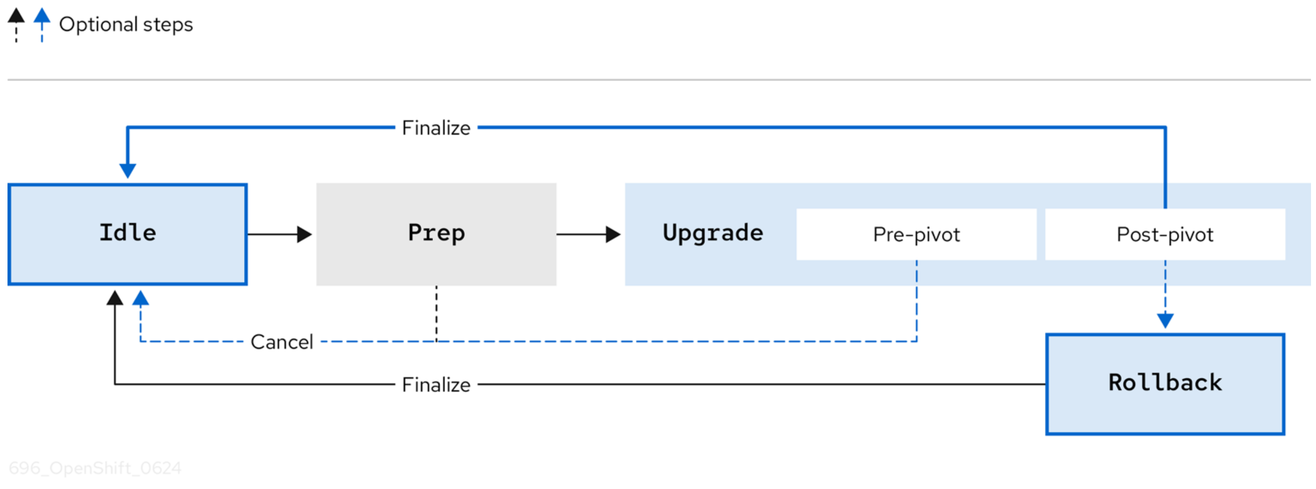
15.1.1.4. (Optional) Rollback stage

The **Rollback** stage can be initiated manually or automatically upon failure. During the **Rollback** stage, the Lifecycle Agent sets the original **ostree** stateroot deployment as default. Then, the node reboots with the previous release of OpenShift Container Platform and application configurations.

WARNING

If you move to the **Idle** stage after a rollback, the Lifecycle Agent cleans up resources that can be used to troubleshoot a failed upgrade.

The Lifecycle Agent initiates an automatic rollback if the upgrade does not complete within a specified time limit. For more information about the automatic rollback, see the relevant *(Optional) Initiating a rollback with Lifecycle Agent* sections.



Additional resources

- Performing an image-based upgrade with Lifecycle Agent
- Performing an image-based upgrade with Lifecycle Agent and GitOps ZTP
- (Optional) Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent
- (Optional) Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent and GitOps ZTP

15.1.2. Guidelines for the image-based upgrade

For a successful image-based upgrade, your deployments must meet certain requirements.

There are different deployment methods in which you can perform the image-based upgrade:

GitOps ZTP
: You use the GitOps Zero Touch Provisioning (ZTP) to deploy and configure your clusters.

Non-GitOps
: You only use Red Hat Advanced Cluster Management (RHACM) to deploy and configure your clusters.

You can perform an image-based upgrade in disconnected environments. For more information about how to mirror images for a disconnected environment, see "Mirroring images for a disconnected installation".

Additional resources

- Mirroring images for a disconnected installation

15.1.2.1. Minimum software version of components

Depending on your deployment method, the image-based upgrade requires the following minimum software versions.

Table 15.1. Minimum software version of components

Component	Software version	Required
Lifecycle Agent	4.16	Yes
OADP Operator	1.3.1	Yes
Managed cluster version	4.14.13	Yes
Hub cluster version	4.16	Yes, if using RHACM
RHACM	2.10.2	Yes, if using RHACM
GitOps ZTP plugin	4.16	Only for GitOps ZTP deployment method

Component	Software version	Required
Red Hat OpenShift GitOps	1.12	Only for GitOps ZTP deployment method
Topology Aware Lifecycle Manager (TALM)	4.16	Only for GitOps ZTP deployment method
Local Storage Operator [1]	4.14	Yes
Logical Volume Manager (LVM) Storage [1]	4.14.2	Yes

1. The persistent storage must be provided by either the LVM Storage or the Local Storage Operator, not both.

15.1.2.2. Hub cluster guidelines

If you are using Red Hat Advanced Cluster Management (RHACM), your hub cluster needs to meet the following conditions:

- To avoid including any RHACM resources in your seed image, you need to disable all optional RHACM add-ons before generating the seed image.
- Your hub cluster must be upgraded at least to the target version before performing an image-based upgrade a target single-node OpenShift cluster.

15.1.2.3. Seed image guidelines

The seed image targets a set of single-node OpenShift clusters with similar configuration. This means that the seed cluster needs to have the same configuration as the target clusters for the following items:

- Performance profile
- **MachineConfig** resources for the target cluster
- IP version

  NOTE

  Dual-stack networking is not supported in this release.

- Set of Day 2 Operators, including the Lifecycle Agent and the OADP Operator
- Disconnected registry
- FIPS configuration
- If the target cluster has multiple IPs and one of them belongs to the subnet that was used for creating the seed image, the upgrade fails if the target cluster’s node IP does not belong to that subnet.

The following configurations only have to partially match on the participating clusters:

- If the target cluster has a proxy configuration, the seed cluster must have a proxy configuration too but the configuration does not have to be the same.
- A dedicated partition on the primary disk for container storage is required on all participating clusters. However, the size and start of the partition does not have to be the same. Only the **spec.config.storage.disks.partitions.label: varlibcontainers** label in the **MachineConfig** CR must match on both the seed and target clusters. For more information about how to create the disk partition, see "Configuring a shared container directory between ostree stateroots" or "Configuring a shared container directory between ostree stateroots when using GitOps ZTP".

For more information about what to include in the seed image, see "Seed image configuration" and "Seed image configuration using the RAN DU profile".

Additional resources

- Configuring a shared container directory between ostree stateroots
- Configuring a shared container directory between ostree stateroots when using GitOps ZTP
- Seed image configuration

15.1.2.4. OADP backup and restore guidelines

With the OADP Operator, you can back up and restore your applications on your target clusters by using **Backup** and **Restore** CRs wrapped in **ConfigMap** objects. The application must work on the current and the target OpenShift Container Platform versions so that they can be restored after the upgrade. The backups must include resources that were initially created.

The following resources must be excluded from the backup:

- **pods**
- **endpoints**
- **controllerrevision**
- **podmetrics**
- **packagemanifest**
- **replicaset**
- **localvolume**, if using Local Storage Operator (LSO)

There are two local storage implementations for single-node OpenShift:

Local Storage Operator (LSO)
: The Lifecycle Agent backs up and restores the required artifacts, including **LocalVolumes** and their associated **StorageClasses**. You must exclude the **persistentVolumes** resource in the application **Backup** CR.

LVM Storage
: You must create the **Backup** and **Restore** CRs for LVM Storage artifacts. You must include the **persistentVolumes** resource in the application **Backup** CR.

For the image-based upgrade, only one Operator is supported on a given target cluster.

IMPORTANT

For both Operators, you must not apply the Operator CRs as extra manifests through the **ImageBasedUpgrade** CR.

The persistent volume contents are preserved and used after the pivot. When you are configuring the **DataProtectionApplication** CR, you must ensure that the **.spec.configuration.restic.enable** is set to **false** for an image-based upgrade. This disables Container Storage Interface integration.

15.1.2.4.1. lca.openshift.io/apply-wave guidelines

The **lca.openshift.io/apply-wave** annotation determines the apply order of **Backup** or **Restore** CRs. The value of the annotation must be a string number. If you define the **lca.openshift.io/apply-wave** annotation in the **Backup** or **Restore** CRs, they are applied in increasing order based on the annotation value. If you do not define the annotation, they are applied together.

The **lca.openshift.io/apply-wave** annotation must be numerically lower in your platform **Restore** CRs, for example RHACM and LVM Storage artifacts, than that of the application. This way, that the platform artifacts are restored before your applications.

If your application includes cluster-scoped resources, you must create separate **Backup** and **Restore** CRs to scope the backup to the specific cluster-scoped resources created by the application. The **Restore** CR for the cluster-scoped resources must be restored before the remaining application **Restore** CR(s).

15.1.2.4.2. lca.openshift.io/apply-label guidelines

You can back up specific resources exclusively with the **lca.openshift.io/apply-label** annotation. Based on which resources you define in the annotation, the Lifecycle Agent applies the **lca.openshift.io/backup: <backup_name>** label and adds the **labelSelector.matchLabels.lca.openshift.io/backup: <backup_name>** label selector to the specified resources when creating the **Backup** CRs.

To use the **lca.openshift.io/apply-label** annotation for backing up specific resources, the resources listed in the annotation must also be included in the **spec** section. If the **lca.openshift.io/apply-label** annotation is used in the **Backup** CR, only the resources listed in the annotation are backed up, even if other resource types are specified in the **spec** section or not.

Example CR

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  name: acm-klusterlet
  namespace: openshift-adp
  annotations:
    lca.openshift.io/apply-label:
rbac.authorization.k8s.io/v1/clusterroles/klusterlet,apps/v1/deployments/open-cluster-management-
agent/klusterlet (1)
  labels:
    velero.io/storage-location: default
spec:
  includedNamespaces:
```

```
 - open-cluster-management-agent
includedClusterScopedResources:
 - clusterroles
includedNamespaceScopedResources:
 - deployments
```

1 The value must be a list of comma-separated objects in **group/version/resource/name** format for cluster-scoped resources or **group/version/resource/namespace/name** format for namespace-scoped resources, and it must be attached to the related **Backup** CR.

15.1.2.5. Extra manifest guidelines

The Lifecycle Agent uses extra manifests to restore your target clusters after rebooting with the new default stateroot deployment and before restoring application artifacts.

Different deployment methods require a different way to apply the extra manifests:

GitOps ZTP

You use the **lca.openshift.io/target-ocp-version: <target_ocp_version>** label to mark the extra manifests that the Lifecycle Agent must extract and apply after the pivot. You can specify the number of manifests labeled with **lca.openshift.io/target-ocp-version** by using the **lca.openshift.io/target-ocp-version-manifest-count** annotation in the **ImageBasedUpgrade** CR. If specified, the Lifecycle Agent verifies that the number of manifests extracted from policies matches the number provided in the annotation during the prep and upgrade stages.

Example for the lca.openshift.io/target-ocp-version-manifest-count annotation

```
apiVersion: lca.openshift.io/v1
kind: ImageBasedUpgrade
metadata:
  annotations:
    lca.openshift.io/target-ocp-version-manifest-count: "5"
  name: upgrade
```

Non-Gitops

You mark your extra manifests with the **lca.openshift.io/apply-wave** annotation to determine the apply order. The labeled extra manifests are wrapped in **ConfigMap** objects and referenced in the **ImageBasedUpgrade** CR that the Lifecycle Agent uses after the pivot.

If the target cluster uses custom catalog sources, you must include them as extra manifests that point to the correct release version.

IMPORTANT

You cannot apply the following items as extra manifests:

- **MachineConfig** objects
- OLM Operator subscriptions

Additional resources

- Performing an image-based upgrade with Lifecycle Agent

- Performing an image-based upgrade with Lifecycle Agent and GitOps ZTP
- Preparing the hub cluster for ZTP
- Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent
- Creating ConfigMap objects for the image-based upgrade with GitOps ZTP
- About installing OADP

15.2. PREPARING FOR AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS

15.2.1. Configuring a shared container directory for the image-based upgrade

Your single-node OpenShift clusters need to have a shared **var/lib/containers** partition for the image-based upgrade. You can do this at install time.

15.2.1.1. Configuring a shared container directory between ostree stateroots

Apply a **MachineConfig** to both the seed and the target clusters during installation time to create a separate partition and share the **/var/lib/containers** directory between the two **ostree** stateroots that will be used during the upgrade process.

IMPORTANT

You must complete this procedure at installation time.

Procedure

- Apply a **MachineConfig** to create a separate partition:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: master
  name: 98-var-lib-containers-partitioned
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      disks:
        - device: /dev/disk/by-id/wwn-<root_disk> (1)
          partitions:
            - label: varlibcontainers
              startMiB: <start_of_partition> (2)
              sizeMiB: <partition_size> (3)
      filesystems:
        - device: /dev/disk/by-partlabel/varlibcontainers
          format: xfs
          mountOptions:
```

```
          - defaults
          - prjquota
        path: /var/lib/containers
        wipeFilesystem: true
  systemd:
    units:
      - contents: |-
          # Generated by Butane
          [Unit]
          Before=local-fs.target
          Requires=systemd-fsck@dev-disk-by\x2dpartlabel-varlibcontainers.service
          After=systemd-fsck@dev-disk-by\x2dpartlabel-varlibcontainers.service

          [Mount]
          Where=/var/lib/containers
          What=/dev/disk/by-partlabel/varlibcontainers
          Type=xfs
          Options=defaults,prjquota

          [Install]
          RequiredBy=local-fs.target
        enabled: true
        name: var-lib-containers.mount
```

1. Specify the root disk.
2. Specify the start of the partition in MiB. If the value is too small, the installation will fail.
3. Specify a minimum size for the partition of 500 GB to ensure adequate disk space for precached images. If the value is too small, the deployments after installation will fail.

15.2.1.2. Configuring a shared container directory between ostree stateroots when using GitOps ZTP

When you are using the GitOps Zero Touch Provisioning (ZTP) workflow, you do the following procedure to create a separate disk partition on both the seed and target cluster and to share the **/var/lib/containers** directory.

IMPORTANT

You must complete this procedure at installation time.

Prerequisites

- Install Butane.

Procedure

1. Create the **storage.bu** file:

```
variant: fcos
version: 1.3.0
storage:
  disks:
```

```
  - device: /dev/disk/by-id/wwn-<root_disk> 1
    wipe_table: false
    partitions:
    - label: var-lib-containers
      start_mib: <start_of_partition> 2
      size_mib: <partition_size> 3
  filesystems:
    - path: /var/lib/containers
      device: /dev/disk/by-partlabel/var-lib-containers
      format: xfs
      wipe_filesystem: true
      with_mount_unit: true
      mount_options:
        - defaults
        - prjquota
```

1. Specify the root disk.
2. Specify the start of the partition in MiB. If the value is too small, the installation will fail.
3. Specify a minimum size for the partition of 500 GB to ensure adequate disk space for precached images. If the value is too small, the deployments after installation will fail.

2. Convert the **storage.bu** to an Ignition file:

```
$ butane storage.bu
```

Example output

```
{"ignition":{"version":"3.2.0"},"storage":{"disks":[{"device":"/dev/disk/by-id/wwn-
0x6b07b250ebb9d0002a33509f24af1f62","partitions":[{"label":"var-lib-
containers","sizeMiB":0,"startMiB":250000}],"wipeTable":false}],"filesystems":
[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":
["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}]},"systemd":{"units":
[{"contents":"# Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-
fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}
```

3. Copy the output into the **.spec.clusters.nodes.ignitionConfigOverride** field in the **SiteConfig** CR:

```
[...]
spec:
  clusters:
    - nodes:
        - ignitionConfigOverride: '{"ignition":{"version":"3.2.0"},"storage":{"disks":
[{"device":"/dev/disk/by-id/wwn-0x6b07b250ebb9d0002a33509f24af1f62","partitions":
[{"label":"var-lib-containers","sizeMiB":0,"startMiB":250000}],"wipeTable":false}],"filesystems":
[{"device":"/dev/disk/by-partlabel/var-lib-containers","format":"xfs","mountOptions":
["defaults","prjquota"],"path":"/var/lib/containers","wipeFilesystem":true}]},"systemd":{"units":
```

```
[{"contents":"# Generated by Butane\n[Unit]\nRequires=systemd-fsck@dev-disk-
by\\x2dpartlabel-var\\x2dlib\\x2dcontainers.service\nAfter=systemd-fsck@dev-disk-
by\\x2dpartlabel-
var\\x2dlib\\x2dcontainers.service\n\n[Mount]\nWhere=/var/lib/containers\nWhat=/dev/disk/by-
partlabel/var-lib-
containers\nType=xfs\nOptions=defaults,prjquota\n\n[Install]\nRequiredBy=local-
fs.target","enabled":true,"name":"var-lib-containers.mount"}]}}'
[...]
```

Verification

1. During or after installation, verify on the hub cluster that the **BareMetalHost** object shows the annotation:

```
$ oc get bmh -n my-sno-ns my-sno -ojson | jq '.metadata.annotations["bmac.agent-
install.openshift.io/ignition-config-overrides"]
```

Example output

```
"{\"ignition\":{\"version\":\"3.2.0\"},\"storage\":{\"disks\":[{\"device\":\"/dev/disk/by-id/wwn-
0x6b07b250ebb9d0002a33509f24af1f62\",\"partitions\":[{\"label\":\"var-lib-
containers\",\"sizeMiB\":0,\"startMiB\":250000}],\"wipeTable\":false}],\"filesystems\":
[{\"device\":\"/dev/disk/by-partlabel/var-lib-containers\",\"format\":\"xfs\",\"mountOptions\":
[\"defaults\",\"prjquota\"],\"path\":\"/var/lib/containers\",\"wipeFilesystem\":true}]},\"systemd\":
{\"units\":[{\"contents\":\"# Generated by Butane\\n[Unit]\\nRequires=systemd-fsck@dev-disk-
by\\\\x2dpartlabel-var\\\\x2dlib\\\\x2dcontainers.service\\nAfter=systemd-fsck@dev-disk-
by\\\\x2dpartlabel-
var\\\\x2dlib\\\\x2dcontainers.service\\n\\n[Mount]\\nWhere=/var/lib/containers\\nWhat=/dev/disk/
by-partlabel/var-lib-
containers\\nType=xfs\\nOptions=defaults,prjquota\\n\\n[Install]\\nRequiredBy=local-
fs.target\",\"enabled\":true,\"name\":\"var-lib-containers.mount\"}]}}"
```

2. After installation, check the single-node OpenShift disk status:

```
# lsblk
```

Example output

```
NAME   MAJ:MIN RM   SIZE RO TYPE MOUNTPOINTS
sda      8:0    0 446.6G  0 disk
├─sda1   8:1    0     1M  0 part
├─sda2   8:2    0   127M  0 part
├─sda3   8:3    0   384M  0 part /boot
├─sda4   8:4    0 243.6G  0 part /var
│                                /sysroot/ostree/deploy/rhcos/var
│                                /usr
│                                /etc
│                                /
│                                /sysroot
└─sda5   8:5    0 202.5G  0 part /var/lib/containers
```

```
# df -h
```

Example output

```
Filesystem      Size  Used Avail Use% Mounted on
devtmpfs        4.0M     0  4.0M   0% /dev
tmpfs           126G   84K  126G   1% /dev/shm
tmpfs            51G   93M   51G   1% /run
/dev/sda4       244G  5.2G  239G   3% /sysroot
tmpfs           126G  4.0K  126G   1% /tmp
/dev/sda5       203G  119G   85G  59% /var/lib/containers
/dev/sda3       350M  110M  218M  34% /boot
tmpfs            26G     0   26G   0% /run/user/1000
```

15.2.2. Installing Operators for the image-based upgrade

Prepare your clusters for the upgrade by installing the Lifecycle Agent and the OADP Operator.

To install the OADP Operator with the non-GitOps method, see "Installing the OADP Operator".

Additional resources

- Installing the OADP Operator
- About backup and snapshot locations and their secrets
- Creating a Backup CR
- Creating a Restore CR

15.2.2.1. Installing the Lifecycle Agent by using the CLI

You can use the OpenShift CLI (**oc**) to install the Lifecycle Agent.

Prerequisites

- Install the OpenShift CLI (**oc**).
- Log in as a user with **cluster-admin** privileges.

Procedure

1. Create a **Namespace** object YAML file for the Lifecycle Agent, for example **lcao-namespace.yaml**:

```
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-lifecycle-agent
  annotations:
    workload.openshift.io/allowed: management
```

   a. Create the **Namespace** CR by running the following command:

```
$ oc create -f lcao-namespace.yaml
```

2. Create an **OperatorGroup** object YAML file for the Lifecycle Agent, for example **lcao-operatorgroup.yaml**:

```
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: openshift-lifecycle-agent
  namespace: openshift-lifecycle-agent
spec:
  targetNamespaces:
  - openshift-lifecycle-agent
```

   a. Create the **OperatorGroup** CR by running the following command:

   ```
   $ oc create -f lcao-operatorgroup.yaml
   ```

3. Create a **Subscription** CR, for example, **lcao-subscription.yaml**:

```
apiVersion: operators.coreos.com/v1
kind: Subscription
metadata:
  name: openshift-lifecycle-agent-subscription
  namespace: openshift-lifecycle-agent
spec:
  channel: "stable"
  name: lifecycle-agent
  source: redhat-operators
  sourceNamespace: openshift-marketplace
```

   a. Create the **Subscription** CR by running the following command:

   ```
   $ oc create -f lcao-subscription.yaml
   ```

Verification

1. To verify that the installation succeeded, inspect the CSV resource by running the following command:

```
$ oc get csv -n openshift-lifecycle-agent
```

Example output

```
NAME                          DISPLAY                    VERSION          REPLACES
PHASE
lifecycle-agent.v4.16.0         Openshift Lifecycle Agent   4.16.0              Succeeded
```

2. Verify that the Lifecycle Agent is up and running by running the following command:

```
$ oc get deploy -n openshift-lifecycle-agent
```

Example output

```
NAME                              READY   UP-TO-DATE   AVAILABLE   AGE
lifecycle-agent-controller-manager   1/1     1            1           14s
```

15.2.2.2. Installing the Lifecycle Agent by using the web console

You can use the OpenShift Container Platform web console to install the Lifecycle Agent.

Prerequisites

- Log in as a user with **cluster-admin** privileges.

Procedure

1. In the OpenShift Container Platform web console, navigate to **Operators** → **OperatorHub**.
2. Search for the **Lifecycle Agent** from the list of available Operators, and then click **Install**.
3. On the **Install Operator** page, under **A specific namespace on the cluster**select **openshift-lifecycle-agent**.
4. Click **Install**.

Verification

1. To confirm that the installation is successful:
    a. Click **Operators** → **Installed Operators**.
    b. Ensure that the Lifecycle Agent is listed in the **openshift-lifecycle-agent** project with a **Status** of **InstallSucceeded**.

> **NOTE**
>
> During installation an Operator might display a **Failed** status. If the installation later succeeds with an **InstallSucceeded** message, you can ignore the **Failed** message.

If the Operator is not installed successfully:

1. Click **Operators** → **Installed Operators**, and inspect the **Operator Subscriptions** and **Install Plans** tabs for any failure or errors under **Status**.
2. Click **Workloads** → **Pods**, and check the logs for pods in the **openshift-lifecycle-agent** project.

15.2.2.3. Installing the Lifecycle Agent with GitOps ZTP

Install the Lifecycle Agent with GitOps Zero Touch Provisioning (ZTP) to do an image-based upgrade.

Prerequisites

- Create a directory called **custom-crs** in the **source-crs** directory. The **source-crs** directory must be in the same location as the **kustomization.yaml** file.

Procedure

1. Create the following CRs in the **openshift-lifecycle-agent** namespace and push them to the **source-crs/custom-crs** directory:

   Example LcaSubscriptionNS.yaml file

   ```
   apiVersion: v1
   kind: Namespace
   metadata:
     name: openshift-lifecycle-agent
     annotations:
       workload.openshift.io/allowed: management
       ran.openshift.io/ztp-deploy-wave: "2"
     labels:
       kubernetes.io/metadata.name: openshift-lifecycle-agent
   ```

   Example LcaSubscriptionOperGroup.yaml file

   ```
   apiVersion: operators.coreos.com/v1
   kind: OperatorGroup
   metadata:
     name: lifecycle-agent-operatorgroup
     namespace: openshift-lifecycle-agent
     annotations:
       ran.openshift.io/ztp-deploy-wave: "2"
   spec:
     targetNamespaces:
       - openshift-lifecycle-agent
   ```

   Example LcaSubscription.yaml file

   ```
   apiVersion: operators.coreos.com/v1
   kind: Subscription
   metadata:
     name: lifecycle-agent
     namespace: openshift-lifecycle-agent
     annotations:
       ran.openshift.io/ztp-deploy-wave: "2"
   spec:
     channel: "stable"
     name: lifecycle-agent
     source: redhat-operators
     sourceNamespace: openshift-marketplace
     installPlanApproval: Manual
     status:
       state: AtLatestKnown
   ```

   Example directory structure

   ```
   ├── kustomization.yaml
   ├── sno
   │   ├── example-cnf.yaml
   │   ├── common-ranGen.yaml
   ```

```
│   ├── group-du-sno-ranGen.yaml
│   ├── group-du-sno-validator-ranGen.yaml
│   └── ns.yaml
├── source-crs
│   ├── custom-crs
│   │   ├── LcaSubscriptionNS.yaml
│   │   ├── LcaSubscriptionOperGroup.yaml
│   │   ├── LcaSubscription.yaml
```

2. Add the CRs to your common **PolicyGenTemplate**:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-common-latest"
  namespace: "ztp-common"
spec:
  bindingRules:
    common: "true"
    du-profile: "latest"
  sourceFiles:
    - fileName: custom-crs/LcaSubscriptionNS.yaml
      policyName: "subscriptions-policy"
    - fileName: custom-crs/LcaSubscriptionOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: custom-crs/LcaSubscription.yaml
      policyName: "subscriptions-policy"
[...]
```

15.2.2.4. Installing and configuring the OADP Operator with GitOps ZTP

Install and configure the OADP Operator with GitOps ZTP before starting the upgrade.

Prerequisites

- Create a directory called **custom-crs** in the **source-crs** directory. The **source-crs** directory must be in the same location as the **kustomization.yaml** file.

Procedure

1. Create the following CRs in the **openshift-adp** namespace and push them to the **source-crs/custom-crs** directory:

   Example OadpSubscriptionNS.yaml file

```
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "2"
  labels:
    kubernetes.io/metadata.name: openshift-adp
```

Example **OadpSubscriptionOperGroup.yaml** file

```yaml
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: redhat-oadp-operator
  namespace: openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "2"
spec:
  targetNamespaces:
  - openshift-adp
```

Example **OadpSubscription.yaml** file

```yaml
apiVersion: operators.coreos.com/v1
kind: Subscription
metadata:
  name: redhat-oadp-operator
  namespace: openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "2"
spec:
  channel: stable-1.3
  name: redhat-oadp-operator
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
status:
  state: AtLatestKnown
```

Example **OadpOperatorStatus.yaml** file

```yaml
apiVersion: operators.coreos.com/v1
kind: Operator
metadata:
  name: redhat-oadp-operator.openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "2"
status:
  components:
    refs:
    - kind: Subscription
      namespace: openshift-adp
      conditions:
      - type: CatalogSourcesUnhealthy
        status: "False"
    - kind: InstallPlan
      namespace: openshift-adp
      conditions:
      - type: Installed
        status: "True"
    - kind: ClusterServiceVersion
      namespace: openshift-adp
    conditions:
    - type: Succeeded
      status: "True"
      reason: InstallSucceeded
```

Example directory structure

```
├── kustomization.yaml
├── sno
│   ├── example-cnf.yaml
│   ├── common-ranGen.yaml
│   ├── group-du-sno-ranGen.yaml
│   ├── group-du-sno-validator-ranGen.yaml
│   └── ns.yaml
├── source-crs
│   ├── custom-crs
│   │   ├── OadpSubscriptionNS.yaml
│   │   ├── OadpSubscriptionOperGroup.yaml
│   │   ├── OadpSubscription.yaml
│   │   ├── OadpOperatorStatus.yaml
```

2. Add the CRs to your common **PolicyGenTemplate**:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-common-latest"
  namespace: "ztp-common"
spec:
  bindingRules:
    common: "true"
    du-profile: "latest"
  sourceFiles:
    - fileName: custom-crs/OadpSubscriptionNS.yaml
      policyName: "subscriptions-policy"
    - fileName: custom-crs/OadpSubscriptionOperGroup.yaml
      policyName: "subscriptions-policy"
    - fileName: custom-crs/OadpSubscription.yaml
      policyName: "subscriptions-policy"
    - fileName: custom-crs/OadpOperatorStatus.yaml
      policyName: "subscriptions-policy"
[...]
```

3. Create the **DataProtectionApplication** CR and the S3 secret:

   a. Create the following CRs in your **source-crs/custom-crs** directory:

   Example DataProtectionApplication.yaml file

```
apiVersion: oadp.openshift.io/v1
kind: DataProtectionApplication
metadata:
  name: dataprotectionapplication
  namespace: openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "100"
spec:
  configuration:
    restic:
      enable: false (1)
    velero:
      defaultPlugins:
        - aws
        - openshift
      resourceTimeout: 10m
  backupLocations:
    - velero:
        config:
          profile: "default"
          region: minio
          s3Url: $url
          insecureSkipTLSVerify: "true"
          s3ForcePathStyle: "true"
        provider: aws
        default: true
        credential:
          key: cloud
          name: cloud-credentials
        objectStorage:
          bucket: $bucketName (2)
          prefix: $prefixName (3)
status:
  conditions:
  - reason: Complete
    status: "True"
    type: Reconciled
```

(1) The **spec.configuration.restic.enable** field must be set to **false** for an image-based upgrade because persistent volume contents are retained and reused after the upgrade.

(2) (3) The bucket defines the bucket name that is created in S3 backend. The prefix defines the name of the subdirectory that will be automatically created in the bucket. The combination of bucket and prefix must be unique for each target cluster to avoid interference between them. To ensure a unique storage directory for each target cluster, you can use the RHACM hub template function, for example, **prefix: {{hub .ManagedClusterName hub}}**.

Example OadpSecret.yaml file

```
apiVersion: v1
kind: Secret
metadata:
  name: cloud-credentials
  namespace: openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "100"
type: Opaque
```

Example OadpBackupStorageLocationStatus.yaml file

```
apiVersion: velero.io/v1
kind: BackupStorageLocation
metadata:
  namespace: openshift-adp
  annotations:
    ran.openshift.io/ztp-deploy-wave: "100"
status:
  phase: Available
```

The **OadpBackupStorageLocationStatus.yaml** CR verifies the availability of backup storage locations created by OADP.

b. Add the CRs to your site **PolicyGenTemplate** with overrides:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: "example-cnf"
  namespace: "ztp-site"
spec:
  bindingRules:
    sites: "example-cnf"
    du-profile: "latest"
  mcp: "master"
  sourceFiles:
    ...
    - fileName: custom-crs/OadpSecret.yaml
      policyName: "config-policy"
      data:
        cloud: <your_credentials> 1
    - fileName: custom-crs/DataProtectionApplication.yaml
      policyName: "config-policy"
      spec:
        backupLocations:
          - velero:
              config:
                region: minio
                s3Url: <your_S3_URL> 2
                profile: "default"
                insecureSkipTLSVerify: "true"
                s3ForcePathStyle: "true"
              provider: aws
              default: true
              credential:
                key: cloud
                name: cloud-credentials
              objectStorage:
                bucket: <your_bucket_name> 3
                prefix: <cluster_name> 4
    - fileName: custom-crs/OadpBackupStorageLocationStatus.yaml
      policyName: "config-policy"
```

1. Specify your credentials for your S3 storage backend.

2. Specify the URL for your S3-compatible bucket.

3 4 The **bucket** defines the bucket name that is created in S3 backend. The **prefix** defines the name of the subdirectory that will be automatically created in the **bucket**. The combination of **bucket** and **prefix** must be unique for each target cluster to avoid interference between them. To ensure a unique storage directory for each target cluster, you can use the RHACM hub template function, for example, **prefix: {{hub .ManagedClusterName hub}}**.

15.2.3. Generating a seed image for the image-based upgrade with Lifecycle Agent

Use the Lifecycle Agent to generate the seed image with the **SeedGenerator** custom resource (CR).

15.2.3.1. Seed image configuration

The seed image targets a set of single-node OpenShift clusters with similar configuration. This means that the seed image must have all of the components and configuration that the seed cluster shares with the target clusters. Therefore, the seed image generated from the seed cluster cannot contain any cluster-specific configuration.

The following table lists the components, resources, and configurations that you must and must not include in your seed image:

Table 15.2. Seed image configuration

Cluster configuration	Include in seed image
Performance profile	Yes
MachineConfig resources for the target cluster	Yes
IP version [1]	Yes
Set of Day 2 Operators, including the Lifecycle Agent and the OADP Operator	Yes
Disconnected registry configuration	Yes
Valid proxy configuration [2]	Yes
FIPS configuration	Yes
Dedicated partition on the primary disk for container storage that matches the size of the target clusters	Yes

Cluster configuration	Include in seed image
Local volumes • **StorageClass** used in **LocalVolume** for LSO • **LocalVolume** for LSO • **LVMCluster** CR for LVMS	No
OADP **DataProtectionApplication** CR	No

1. Dual-stack networking is not supported in this release.
2. The proxy configuration does not have to be the same.

15.2.3.1.1. Seed image configuration using the RAN DU profile

The following table lists the components, resources, and configurations that you must and must not include in the seed image when using the RAN DU profile:

Table 15.3. Seed image configuration with RAN DU profile

Resource	Include in seed image
All extra manifests that are applied as part of Day 0 installation	Yes
All Day 2 Operator subscriptions	Yes
ClusterLogging.yaml	Yes
DisableOLMPprof.yaml	Yes
TunedPerformancePatch.yaml	Yes
PerformanceProfile.yaml	Yes
SriovOperatorConfig.yaml	Yes
DisableSnoNetworkDiag.yaml	Yes
StorageClass.yaml	No, if it is used in **StorageLV.yaml**
StorageLV.yaml	No
StorageLVMCluster.yaml	No

Table 15.4. Seed image configuration with RAN DU profile for extra manifests

Resource	Apply as extra manifest
ClusterLogForwarder.yaml	Yes
ReduceMonitoringFootprint.yaml	Yes
SriovFecClusterConfig.yaml	Yes
PtpOperatorConfigForEvent.yaml	Yes
DefaultCatsrc.yaml	Yes
PtpConfig.yaml	If the interfaces of the target cluster are common with the seed cluster, you can include them in the seed image. Otherwise, apply it as extra manifests.
SriovNetwork.yamlSriovNetworkNodePolicy.yaml	If the configuration, including namespaces, is exactly the same on both the seed and target cluster, you can include them in the seed image. Otherwise, apply them as extra manifests.

15.2.3.2. Generating a seed image with the Lifecycle Agent

Use the Lifecycle Agent to generate the seed image with the **SeedGenerator** CR. The Operator checks for required system configurations, performs any necessary system cleanup before generating the seed image, and launches the image generation. The seed image generation includes the following tasks:

- Stopping cluster Operators
- Preparing the seed image configuration
- Generating and pushing the seed image to the image repository specified in the **SeedGenerator** CR
- Restoring cluster Operators
- Expiring seed cluster certificates
- Generating new certificates for the seed cluster
- Restoring and updating the **SeedGenerator** CR on the seed cluster

Prerequisites

- Configure a shared container directory on the seed cluster.
- Install the OADP Operator and the Lifecycle Agent on the seed cluster.

Procedure

1. Detach the cluster from the hub to delete any cluster-specific resources from the seed cluster that must not be in the seed image:

   a. If you are using RHACM, manually detach the seed cluster by running the following command:

   ```
   $ oc delete managedcluster sno-worker-example
   ```

      i. Wait until the **ManagedCluster** CR is removed. After the CR is removed, create the proper **SeedGenerator** CR. The Lifecycle Agent cleans up the RHACM artifacts.

   b. If you are using GitOps ZTP, detach your cluster by removing the seed cluster's **SiteConfig** CR from the **kustomization.yaml**:

      i. Remove your seed cluster's **SiteConfig** CR from the **kustomization.yaml**.

      ```
      apiVersion: kustomize.config.k8s.io/v1beta1
      kind: Kustomization

      generators:
      #- example-seed-sno1.yaml
      - example-target-sno2.yaml
      - example-target-sno3.yaml
      ```

      ii. Commit the **kustomization.yaml** changes in your Git repository and push the changes. The ArgoCD pipeline detects the changes and removes the managed cluster.

2. Create the **Secret**:

   a. Create the authentication file by running the following commands:

   ```
   $ MY_USER=myuserid
   $ AUTHFILE=/tmp/my-auth.json
   $ podman login --authfile ${AUTHFILE} -u ${MY_USER} quay.io/${MY_USER}
   ```

   ```
   $ base64 -w 0 ${AUTHFILE} ; echo
   ```

   b. Copy the output into the **seedAuth** field in the **Secret** YAML file named **seedgen** in the **openshift-lifecycle-agent** namespace:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: seedgen (1)
     namespace: openshift-lifecycle-agent
   type: Opaque
   data:
     seedAuth: <encoded_AUTHFILE> (2)
   ```

   (1) The **Secret** resource must have the **name: seedgen** and **namespace: openshift-lifecycle-agent** fields.

   (2) Specifies a base64-encoded authfile for write-access to the registry for pushing the generated seed images.

c. Apply the **Secret** by running the following command:

```
$ oc apply -f secretseedgenerator.yaml
```

3. Create the **SeedGenerator** CR:

```
apiVersion: lca.openshift.io/v1
kind: SeedGenerator
metadata:
  name: seedimage (1)
spec:
  seedImage: <seed_container_image> (2)
```

(1) The **SeedGenerator** CR must be named **seedimage**.

(2) Specify the container image URL, for example, **quay.io/example/seed-container-image:<tag>**. It is recommended to use the **<seed_cluster_name>:<ocp_version>** format.

4. Generate the seed image by running the following command:

```
$ oc apply -f seedgenerator.yaml
```

IMPORTANT

The cluster reboots and loses API capabilities while the Lifecycle Agent generates the seed image. Applying the **SeedGenerator** CR stops the **kubelet** and the CRI-O operations, then it starts the image generation.

If you want to generate more seed images, you must provision a new seed cluster with the version that you want to generate a seed image from.

Verification

1. After the cluster recovers and it is available, you can check the status of the **SeedGenerator** CR by running the following command:

```
$ oc get seedgenerator -o yaml
```

Example output

```
status:
  conditions:
  - lastTransitionTime: "2024-02-13T21:24:26Z"
    message: Seed Generation completed
    observedGeneration: 1
    reason: Completed
    status: "False"
    type: SeedGenInProgress
  - lastTransitionTime: "2024-02-13T21:24:26Z"
    message: Seed Generation completed
    observedGeneration: 1
    reason: Completed
    status: "True"
    type: SeedGenCompleted (1)
  observedGeneration: 1
```

(1) The seed image generation is complete.

Additional resources

- Configuring a shared container directory between ostree stateroots
- Configuring a shared container directory between ostree stateroots when using GitOps ZTP

15.2.4. Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent

The Lifecycle Agent needs all your OADP resources, extra manifests, and custom catalog sources wrapped in a **ConfigMap** object to process them for the image-based upgrade.

15.2.4.1. Creating OADP ConfigMap objects for the image-based upgrade with Lifecycle Agent

Create your OADP resources that are used to back up and restore your resources during the upgrade.

Prerequisites

- Generate a seed image from a compatible seed cluster.
- Create OADP backup and restore resources.
- Create a separate partition on the target cluster for the container images that is shared between stateroots. For more information about, see "Configuring a shared container directory for the image-based upgrade".
- Deploy a version of Lifecycle Agent that is compatible with the version used with the seed image.
- Install the OADP Operator, the **DataProtectionApplication** CR, and its secret on the target cluster.
- Create an S3-compatible storage solution and a ready-to-use bucket with proper credentials configured. For more information, see "About installing OADP".

Procedure

1. Create the OADP **Backup** and **Restore** CRs for platform artifacts in the same namespace where the OADP Operator is installed, which is **openshift-adp**.

    a. If the target cluster is managed by RHACM, add the following YAML file for backing up and restoring RHACM artifacts:

    PlatformBackupRestore.yaml for RHACM

    ```
    apiVersion: velero.io/v1
    kind: Backup
    ```

```
metadata:
  name: acm-klusterlet
  annotations:
    lca.openshift.io/apply-label: "apps/v1/deployments/open-cluster-management-
agent/klusterlet,v1/secrets/open-cluster-management-agent/bootstrap-hub-
kubeconfig,rbac.authorization.k8s.io/v1/clusterroles/klusterlet,v1/serviceaccounts/open-
cluster-management-agent/klusterlet,scheduling.k8s.io/v1/priorityclasses/klusterlet-
critical,rbac.authorization.k8s.io/v1/clusterroles/open-cluster-management:klusterlet-
admin-aggregate-
clusterrole,rbac.authorization.k8s.io/v1/clusterrolebindings/klusterlet,operator.open-
cluster-
management.io/v1/klusterlets/klusterlet,apiextensions.k8s.io/v1/customresourcedefinitions/k
usterlets.operator.open-cluster-management.io,v1/secrets/open-cluster-management-
agent/open-cluster-management-image-pull-credentials" 1
  labels:
    velero.io/storage-location: default
  namespace: openshift-adp
spec:
  includedNamespaces:
  - open-cluster-management-agent
  includedClusterScopedResources:
  - klusterlets.operator.open-cluster-management.io
  - clusterroles.rbac.authorization.k8s.io
  - clusterrolebindings.rbac.authorization.k8s.io
  - priorityclasses.scheduling.k8s.io
  includedNamespaceScopedResources:
  - deployments
  - serviceaccounts
  - secrets
  excludedNamespaceScopedResources: []
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: acm-klusterlet
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "1"
spec:
  backupName:
    acm-klusterlet
```

1. If your **multiclusterHub** CR does not have **.spec.imagePullSecret** defined and the secret does not exist on the **open-cluster-management-agent** namespace in your hub cluster, remove **v1/secrets/open-cluster-management-agent/open-cluster-management-image-pull-credentials**.

b. If you created persistent volumes on your cluster through LVM Storage, add the following YAML file for LVM Storage artifacts:

PlatformBackupRestoreLvms.yaml for LVM Storage

```
apiVersion: velero.io/v1
```

```
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: lvmcluster
  namespace: openshift-adp
spec:
  includedNamespaces:
    - openshift-storage
  includedNamespaceScopedResources:
    - lvmclusters
    - lvmvolumegroups
    - lvmvolumegroupnodestatuses
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: lvmcluster
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "2" (1)
spec:
  backupName:
    lvmcluster
```

(1) The **lca.openshift.io/apply-wave** value must be lower than the values specified in the application **Restore** CRs.

2. (Optional) If you need to restore applications after the upgrade, create the OADP **Backup** and **Restore** CRs for your application in the **openshift-adp** namespace.

   a. Create the OADP CRs for cluster-scoped application artifacts in the **openshift-adp** namespace.

   Example OADP CRs for cluster-scoped application artifacts for LSO and LVM Storage

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  annotations:
    lca.openshift.io/apply-label:
"apiextensions.k8s.io/v1/customresourcedefinitions/test.example.com,security.openshift.io/v
1/securitycontextconstraints/test,rbac.authorization.k8s.io/v1/clusterroles/test-
role,rbac.authorization.k8s.io/v1/clusterrolebindings/system:openshift:scc:test" (1)
  name: backup-app-cluster-resources
  labels:
    velero.io/storage-location: default
  namespace: openshift-adp
spec:
  includedClusterScopedResources:
  - customresourcedefinitions
  - securitycontextconstraints
  - clusterrolebindings
  - clusterroles
  excludedClusterScopedResources:
  - Namespace
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app-cluster-resources
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "3" (2)
spec:
  backupName:
    backup-app-cluster-resources
```

(1) Replace the example resource name with your actual resources.

(2) The **lca.openshift.io/apply-wave** value must be higher than the value in the platform **Restore** CRs and lower than the value in the application namespace-scoped **Restore** CR.

b. Create the OADP CRs for your namespace-scoped application artifacts.

Example OADP CRs namespace-scoped application artifacts when LSO is used

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: backup-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  - configmaps
  - cronjobs
  - services
  - job
  - poddisruptionbudgets
  - <application_custom_resources> (1)
  excludedClusterScopedResources:
  - persistentVolumes
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "4"
spec:
  backupName:
    backup-app
```

1 Define custom resources for your application.

Example OADP CRs namespace-scoped application artifacts when LVM Storage is used

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: backup-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  - configmaps
  - cronjobs
  - services
  - job
  - poddisruptionbudgets
  - <application_custom_resources> 1
  includedClusterScopedResources:
  - persistentVolumes 2
  - logicalvolumes.topolvm.io 3
  - volumesnapshotcontents 4
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "4"
spec:
  backupName:
    backup-app
  restorePVs: true
```

```
restoreStatus:
  includedResources:
  - logicalvolumes (5)
```

(1) Define custom resources for your application.

(2) Required field.

(3) Required field

(4) Optional if you use LVM Storage volume snapshots.

(5) Required field.

IMPORTANT

The same version of the applications must function on both the current and the target release of OpenShift Container Platform.

3. Create the **ConfigMap** object for your OADP CRs by running the following command:

```
$ oc create configmap oadp-cm-example --from-file=example-oadp-resources.yaml=
<path_to_oadp_crs> -n openshift-adp
```

4. Patch the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade \
  -p='{"spec": {"oadpContent": [{"name": "oadp-cm-example", "namespace": "openshift-
adp"}]}}' \
  --type=merge -n openshift-lifecycle-agent
```

Additional resources

- Configuring a shared container directory between ostree stateroots
- About installing OADP

15.2.4.2. Creating ConfigMap objects of extra manifests for the image-based upgrade with Lifecycle Agent

You can create additional manifests that you want to apply to the target cluster.

Procedure

1. Create a YAML file that contains your extra manifests, such as SR-IOV.

Example SR-IOV resources

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: "example-sriov-node-policy"
  namespace: openshift-sriov-network-operator
spec:
  deviceType: vfio-pci
  isRdma: false
  nicSelector:
    pfNames: [ens1f0]
  nodeSelector:
    node-role.kubernetes.io/master: ""
  mtu: 1500
  numVfs: 8
  priority: 99
  resourceName: example-sriov-node-policy
---
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: "example-sriov-network"
  namespace: openshift-sriov-network-operator
spec:
  ipam: |-
    {
    }
  linkState: auto
  networkNamespace: sriov-namespace
  resourceName: example-sriov-node-policy
  spoofChk: "on"
  trust: "off"
```

2. Create the **ConfigMap** object by running the following command:

```
$ oc create configmap example-extra-manifests-cm --from-file=example-extra-
manifests.yaml=<path_to_extramanifest> -n openshift-lifecycle-agent
```

3. Patch the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade \
  -p='{"spec": {"extraManifests": [{"name": "example-extra-manifests-cm", "namespace":
"openshift-lifecycle-agent"}]}}' \
  --type=merge -n openshift-lifecycle-agent
```

15.2.4.3. Creating ConfigMap objects of custom catalog sources for the image-based upgrade with Lifecycle Agent

You can keep your custom catalog sources after the upgrade by generating a **ConfigMap** object for your catalog sources and adding them to the **spec.extraManifest** field in the **ImageBasedUpgrade** CR. For more information about catalog sources, see "Catalog source".

Procedure

1. Create a YAML file that contains the **CatalogSource** CR:

```
apiVersion: operators.coreos.com/v1
kind: CatalogSource
metadata:
  name: example-catalogsources
  namespace: openshift-marketplace
spec:
  sourceType: grpc
  displayName: disconnected-redhat-operators
  image: quay.io/example-org/example-catalog:v1
```

2. Create the **ConfigMap** object by running the following command:

```
$ oc create configmap example-catalogsources-cm --from-file=example-
catalogsources.yaml=<path_to_catalogsource_cr> -n openshift-lifecycle-agent
```

3. Patch the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade \
  -p='{"spec": {"extraManifests": [{"name": "example-catalogsources-cm", "namespace":
"openshift-lifecycle-agent"}]}}' \
  --type=merge -n openshift-lifecycle-agent
```

Additional resources

- Catalog source
- Performing an image-based upgrade with Lifecycle Agent

15.2.5. Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent using GitOps ZTP

Create your OADP resources, extra manifests, and custom catalog sources wrapped in a **ConfigMap** object to prepare for the image-based upgrade.

15.2.5.1. Creating OADP resources for the image-based upgrade with GitOps ZTP

Prepare your OADP resources to restore your application after an upgrade.

Prerequisites

- Provision one or more managed clusters with GitOps ZTP.
- Log in as a user with **cluster-admin** privileges.
- Generate a seed image from a compatible seed cluster.
- Create a separate partition on the target cluster for the container images that is shared between stateroots. For more information, see "Configuring a shared container directory between ostree stateroots when using GitOps ZTP".
- Deploy a version of Lifecycle Agent that is compatible with the version used with the seed image.
- Install the OADP Operator, the **DataProtectionApplication** CR, and its secret on the target cluster.

- Create an S3-compatible storage solution and a ready-to-use bucket with proper credentials configured. For more information, see "Installing and configuring the OADP Operator with GitOps ZTP".

Procedure

1. Ensure that your Git repository that you use with the ArgoCD policies application contains the following directory structure:

```
├── source-crs/
│   ├── ibu/
│   │    ├── ImageBasedUpgrade.yaml
│   │    ├── PlatformBackupRestore.yaml
│   │    ├── PlatformBackupRestoreLvms.yaml
├── ...
├── ibu-upgrade-ranGen.yaml
├── kustomization.yaml
```

IMPORTANT

The **kustomization.yaml** file must be located in the same directory structure as previously shown to reference the **ibu-upgrade-ranGen.yaml** manifest.

The **source-crs/ibu/PlatformBackupRestore.yaml** file is provided in the ZTP container image.

PlatformBackupRestore.yaml

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  name: acm-klusterlet
  annotations:
    lca.openshift.io/apply-label: "apps/v1/deployments/open-cluster-management-
agent/klusterlet,v1/secrets/open-cluster-management-agent/bootstrap-hub-
kubeconfig,rbac.authorization.k8s.io/v1/clusterroles/klusterlet,v1/serviceaccounts/open-
cluster-management-agent/klusterlet,scheduling.k8s.io/v1/priorityclasses/klusterlet-
critical,rbac.authorization.k8s.io/v1/clusterroles/open-cluster-management:klusterlet-admin-
aggregate-
clusterrole,rbac.authorization.k8s.io/v1/clusterrolebindings/klusterlet,operator.open-cluster-
management.io/v1/klusterlets/klusterlet,apiextensions.k8s.io/v1/customresourcedefinitions/klust
rlets.operator.open-cluster-management.io,v1/secrets/open-cluster-management-
agent/open-cluster-management-image-pull-credentials" 1
  labels:
    velero.io/storage-location: default
  namespace: openshift-adp
spec:
  includedNamespaces:
  - open-cluster-management-agent
  includedClusterScopedResources:
  - klusterlets.operator.open-cluster-management.io
  - clusterroles.rbac.authorization.k8s.io
  - clusterrolebindings.rbac.authorization.k8s.io
  - priorityclasses.scheduling.k8s.io
  includedNamespaceScopedResources:
```

```
  - deployments
  - serviceaccounts
  - secrets
  excludedNamespaceScopedResources: []
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: acm-klusterlet
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "1"
spec:
  backupName:
    acm-klusterlet
```

1. If your **multiclusterHub** CR does not have **.spec.imagePullSecret** defined and the secret does not exist on the **open-cluster-management-agent** namespace in your hub cluster, remove **v1/secrets/open-cluster-management-agent/open-cluster-management-image-pull-credentials**.

If you use LVM Storage to create persistent volumes, you can use the **source-crs/ibu/PlatformBackupRestoreLvms.yaml** provided in the ZTP container image to back up your LVM Storage resources.

PlatformBackupRestoreLvms.yaml

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: lvmcluster
  namespace: openshift-adp
spec:
  includedNamespaces:
    - openshift-storage
  includedNamespaceScopedResources:
    - lvmclusters
    - lvmvolumegroups
    - lvmvolumegroupnodestatuses
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: lvmcluster
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "2" (1)
```

```
spec:
  backupName:
    lvmcluster
```

1 The **lca.openshift.io/apply-wave** value must be lower than the values specified in the application **Restore** CRs.

2. Optional: If you need to restore applications after the upgrade, create the OADP **Backup** and **Restore** CRs for your application in the **openshift-adp** namespace:

   a. Create the OADP CRs for cluster-scoped application artifacts in the **openshift-adp** namespace:

Example OADP CRs for cluster-scoped application artifacts for LSO and LVM Storage

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  annotations:
    lca.openshift.io/apply-label:
"apiextensions.k8s.io/v1/customresourcedefinitions/test.example.com,security.openshift.io/v
1/securitycontextconstraints/test,rbac.authorization.k8s.io/v1/clusterroles/test-
role,rbac.authorization.k8s.io/v1/clusterrolebindings/system:openshift:scc:test" 1
  name: backup-app-cluster-resources
  labels:
    velero.io/storage-location: default
  namespace: openshift-adp
spec:
  includedClusterScopedResources:
  - customresourcedefinitions
  - securitycontextconstraints
  - clusterrolebindings
  - clusterroles
  excludedClusterScopedResources:
  - Namespace
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app-cluster-resources
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "3" 2
spec:
  backupName:
    backup-app-cluster-resources
```

1 Replace the example resource name with your actual resources.

2

The **lca.openshift.io/apply-wave** value must be higher than the value in the platform **Restore** CRs and lower than the value in the application namespace-scoped **Restore**

b. Create the OADP CRs for your namespace-scoped application artifacts in the **source-crs/custom-crs** directory:

Example OADP CRs namespace-scoped application artifacts when LSO is used

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: backup-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  - configmaps
  - cronjobs
  - services
  - job
  - poddisruptionbudgets
  - <application_custom_resources> 1
  excludedClusterScopedResources:
  - persistentVolumes
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "4"
spec:
  backupName:
    backup-app
```

1 Define custom resources for your application.

Example OADP CRs namespace-scoped application artifacts when LVM Storage is used

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: backup-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  - configmaps
  - cronjobs
  - services
  - job
  - poddisruptionbudgets
  - <application_custom_resources> 1
  includedClusterScopedResources:
  - persistentVolumes 2
  - logicalvolumes.topolvm.io 3
  - volumesnapshotcontents 4
---
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: test-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "4"
spec:
  backupName:
    backup-app
  restorePVs: true
  restoreStatus:
    includedResources:
    - logicalvolumes 5
```

1 Define custom resources for your application.

2 Required field.

3 Required field

4 Optional if you use LVM Storage volume snapshots.

5 Required field.

IMPORTANT

The same version of the applications must function on both the current and the target release of OpenShift Container Platform.

3. Create the **oadp-cm ConfigMap** object through the **oadp-cm-policy** in a new **PolicyGenTemplate** called **ibu-upgrade-ranGen.yaml**:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: example-group-ibu
  namespace: "ztp-group"
spec:
  bindingRules:
    group-du-sno: ""
  mcp: "master"
  evaluationInterval:
    compliant: 10s
    noncompliant: 10s
  sourceFiles:
  - fileName: ConfigMapGeneric.yaml
    complianceType: mustonlyhave
    policyName: "oadp-cm-policy"
    metadata:
      name: oadp-cm
      namespace: openshift-adp
```

4. Create a **kustomization.yaml** with the following content:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

generators: (1)
- ibu-upgrade-ranGen.yaml

configMapGenerator: (2)
- files:
  - source-crs/ibu/PlatformBackupRestore.yaml
  #- source-crs/custom-crs/ApplicationClusterScopedBackupRestore.yaml
  #- source-crs/custom-crs/ApplicationApplicationBackupRestoreLso.yaml
  name: oadp-cm
  namespace: ztp-group
generatorOptions:
  disableNameSuffixHash: true


patches: (3)
- target:
    group: policy.open-cluster-management.io
    version: v1
    kind: Policy
    name: group-ibu-oadp-cm-policy
  patch: |-
    - op: replace
      path: /spec/policy-templates/0/objectDefinition/spec/object-
templates/0/objectDefinition/data
      value: '{{hub copyConfigMapData "ztp-group" "oadp-cm" hub}}'
```

(1) Generates the **oadp-cm-policy**.

2 Creates the **oadp-cm ConfigMap** object on the hub cluster with **Backup** and **Restore** CRs.

3 Overrides the data field of **ConfigMap** added in **oadp-cm-policy**. A hub template is used to propagate the **oadp-cm ConfigMap** to all target clusters.

5. Push the changes to your Git repository.

Additional resources

- Configuring a shared container directory between ostree stateroots when using GitOps ZTP
- Installing and configuring the OADP Operator with GitOps ZTP

15.2.5.2. Labeling extra manifests for the image-based upgrade with GitOps ZTP

Label your extra manifests so that the Lifecycle Agent can extract resources that are labeled with the **lca.openshift.io/target-ocp-version: <target_version>** label.

Prerequisites

- Provision one or more managed clusters with GitOps ZTP.
- Log in as a user with **cluster-admin** privileges.
- Generate a seed image from a compatible seed cluster.
- Create a separate partition on the target cluster for the container images that is shared between stateroots. For more information, see "Configuring a shared container directory between ostree stateroots when using GitOps ZTP".
- Deploy a version of Lifecycle Agent that is compatible with the version used with the seed image.

Procedure

1. Label your required extra manifests with the **lca.openshift.io/target-ocp-version: <target_version>** label in your existing **PolicyGenTemplate** CR:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: example-sno
spec:
  bindingRules:
    sites: "example-sno"
    du-profile: "4.15"
  mcp: "master"
  sourceFiles:
    - fileName: SriovNetwork.yaml
      policyName: "config-policy"
      metadata:
        name: "sriov-nw-du-fh"
        labels:
          lca.openshift.io/target-ocp-version: "4.15" 1
  spec:
    resourceName: du_fh
    vlan: 140
- fileName: SriovNetworkNodePolicy.yaml
  policyName: "config-policy"
  metadata:
    name: "sriov-nnp-du-fh"
    labels:
      lca.openshift.io/target-ocp-version: "4.15"
  spec:
    deviceType: netdevice
    isRdma: false
    nicSelector:
      pfNames: ["ens5f0"]
    numVfs: 8
    priority: 10
    resourceName: du_fh
- fileName: SriovNetwork.yaml
  policyName: "config-policy"
  metadata:
    name: "sriov-nw-du-mh"
    labels:
      lca.openshift.io/target-ocp-version: "4.15"
  spec:
    resourceName: du_mh
    vlan: 150
- fileName: SriovNetworkNodePolicy.yaml
  policyName: "config-policy"
  metadata:
    name: "sriov-nnp-du-mh"
    labels:
      lca.openshift.io/target-ocp-version: "4.15"
  spec:
    deviceType: vfio-pci
    isRdma: false
    nicSelector:
      pfNames: ["ens7f0"]
    numVfs: 8
    priority: 10
    resourceName: du_mh
- fileName: DefaultCatsrc.yaml 2
  policyName: "config-policy"
  metadata:
    name: default-cat-source
    namespace: openshift-marketplace
    labels:
        lca.openshift.io/target-ocp-version: "4.15"
  spec:
      displayName: default-cat-source
      image: quay.io/example-org/example-catalog:v1
```

1 Ensure that the **lca.openshift.io/target-ocp-version** label matches either the y-stream or the z-stream of the target OpenShift Container Platform version that is specified in the **spec.seedImageRef.version** field of the **ImageBasedUpgrade** CR. The Lifecycle Agent only applies the CRs that match the specified version.

2 If you do not want to use custom catalog sources, remove this entry.

2. Push the changes to your Git repository.

Additional resources

- Configuring a shared container directory between ostree stateroots when using GitOps ZTP
- Performing an image-based upgrade for single-node OpenShift clusters using GitOps ZTP

15.3. PERFORMING AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS

You can use the Lifecycle Agent to do a manual image-based upgrade of a single-node OpenShift cluster.

When you deploy the Lifecycle Agent on a cluster, an **ImageBasedUpgrade** CR is automatically created. You update this CR to specify the image repository of the seed image and to move through the different stages.

15.3.1. Moving to the Prep stage of the image-based upgrade with Lifecycle Agent

When you deploy the Lifecycle Agent on a cluster, an **ImageBasedUpgrade** custom resource (CR) is automatically created.

After you created all the resources that you need during the upgrade, you can move on to the **Prep** stage. For more information, see the "Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent" section.

Prerequisites

- You have created resources to back up and restore your clusters.

Procedure

1. Check that you have patched your **ImageBasedUpgrade** CR:

```
apiVersion: lca.openshift.io/v1
kind: ImageBasedUpgrade
metadata:
  name: upgrade
spec:
  stage: Idle
  seedImageRef:
    version: 4.15.2 (1)
    image: <seed_container_image> (2)
    pullSecretRef: <seed_pull_secret> (3)
  autoRollbackOnFailure: {}
#   initMonitorTimeoutSeconds: 1800 (4)
  extraManifests: (5)
  - name: example-extra-manifests-cm
    namespace: openshift-lifecycle-agent
  - name: example-catalogsources-cm
```

```
    namespace: openshift-lifecycle-agent
  oadpContent: 6
  - name: oadp-cm-example
    namespace: openshift-adp
```

1. Specify the target platform version. The value must match the version of the seed image.
2. Specify the repository where the target cluster can pull the seed image from.
3. Specify the reference to a secret with credentials to pull container images if the images are in a private registry.
4. (Optional) Specify the time frame in seconds to roll back if the upgrade does not complete within that time frame after the first reboot. If not defined or set to **0**, the default value of **1800** seconds (30 minutes) is used.
5. (Optional) Specify the list of **ConfigMap** resources that contain your custom catalog sources to retain after the upgrade and your extra manifests to apply to the target cluster that are not part of the seed image.
6. Add the **oadpContent** section with the OADP **ConfigMap** information.

2. To start the **Prep** stage, change the value of the **stage** field to **Prep** in the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Prep"}}' --
type=merge -n openshift-lifecycle-agent
```

If you provide **ConfigMap** objects for OADP resources and extra manifests, Lifecycle Agent validates the specified **ConfigMap** objects during the **Prep** stage. You might encounter the following issues:

- Validation warnings or errors if the Lifecycle Agent detects any issues with the **extraManifests** parameters.
- Validation errors if the Lifecycle Agent detects any issues with the **oadpContent** parameters.

Validation warnings do not block the **Upgrade** stage but you must decide if it is safe to proceed with the upgrade. These warnings, for example missing CRDs, namespaces, or dry run failures, update the **status.conditions** for the **Prep** stage and **annotation** fields in the **ImageBasedUpgrade** CR with details about the warning.

Example validation warning

```
[...]
metadata:
annotations:
  extra-manifest.lca.openshift.io/validation-warning: '...'
[...]
```

However, validation errors, such as adding **MachineConfig** or Operator manifests to extra manifests, cause the **Prep** stage to fail and block the **Upgrade** stage.

When the validations pass, the cluster creates a new **ostree** stateroot, which involves pulling and unpacking the seed image, and running host-level commands. Finally, all the required images are precached on the target cluster.

Verification

- Check the status of the **ImageBasedUpgrade** CR by running the following command:

```
$ oc get ibu -o yaml
```

Example output

```
conditions:
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: In progress
  observedGeneration: 13
  reason: InProgress
  status: "False"
  type: Idle
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Prep completed
  observedGeneration: 13
  reason: Completed
  status: "False"
  type: PrepInProgress
- lastTransitionTime: "2024-01-01T09:00:00Z"
  message: Prep stage completed successfully
  observedGeneration: 13
  reason: Completed
  status: "True"
  type: PrepCompleted
observedGeneration: 13
validNextStages:
- Idle
- Upgrade
```

Additional resources

- Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent

15.3.2. Moving to the Upgrade stage of the image-based upgrade with Lifecycle Agent

After you generate the seed image and complete the **Prep** stage, you can upgrade the target cluster. During the upgrade process, the OADP Operator creates a backup of the artifacts specified in the OADP custom resources (CRs), then the Lifecycle Agent upgrades the cluster.

If the upgrade fails or stops, an automatic rollback is initiated. If you have an issue after the upgrade, you can initiate a manual rollback. For more information about manual rollback, see "(Optional) Initiating a rollback with Lifecycle Agent".

Prerequisites

- Complete the **Prep** stage.

Procedure

1. To move to the **Upgrade** stage, change the value of the **stage** field to **Upgrade** in the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Upgrade"}}' -
-type=merge
```

2. Check the status of the **ImageBasedUpgrade** CR by running the following command:

```
$ oc get ibu -o yaml
```

Example output

```
status:
  conditions:
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: In progress
    observedGeneration: 5
    reason: InProgress
    status: "False"
    type: Idle
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: Prep completed
    observedGeneration: 5
    reason: Completed
    status: "False"
    type: PrepInProgress
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: Prep completed successfully
    observedGeneration: 5
    reason: Completed
    status: "True"
    type: PrepCompleted
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: |-
      Waiting for system to stabilize: one or more health checks failed
        - one or more ClusterOperators not yet ready: authentication
        - one or more MachineConfigPools not yet ready: master
        - one or more ClusterServiceVersions not yet ready: sriov-fec.v2.8.0
    observedGeneration: 1
    reason: InProgress
    status: "True"
    type: UpgradeInProgress
  observedGeneration: 1
  rollbackAvailabilityExpiration: "2024-05-19T14:01:52Z"
  validNextStages:
  - Rollback
```

The OADP Operator creates a backup of the data specified in the OADP **Backup** and **Restore** CRs and the target cluster reboots.

3. Monitor the status of the CR by running the following command:

```
$ oc get ibu -o yaml
```

–

4. If you are satisfied with the upgrade, finalize the changes by patching the value of the **stage** field to **Idle** in the **ImageBasedUpgrade** CR by running the following command:

```
$ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Idle"}}' --
type=merge
```

IMPORTANT

You cannot roll back the changes once you move to the **Idle** stage after an upgrade.

The Lifecycle Agent deletes all resources created during the upgrade process.

Verification

1. Check the status of the **ImageBasedUpgrade** CR by running the following command:

```
$ oc get ibu -o yaml
```

Example output

```
status:
  conditions:
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: In progress
    observedGeneration: 5
    reason: InProgress
    status: "False"
    type: Idle
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: Prep completed
    observedGeneration: 5
    reason: Completed
    status: "False"
    type: PrepInProgress
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: Prep completed successfully
    observedGeneration: 5
    reason: Completed
    status: "True"
    type: PrepCompleted
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: Upgrade completed
    observedGeneration: 1
    reason: Completed
    status: "False"
    type: UpgradeInProgress
  - lastTransitionTime: "2024-01-01T09:00:00Z"
    message: Upgrade completed
    observedGeneration: 1
    reason: Completed
    status: "True"
    type: UpgradeCompleted
    observedGeneration: 1
    rollbackAvailabilityExpiration: "2024-01-01T09:00:00Z"
    validNextStages:
    - Idle
    - Rollback
```

2. Check the status of the cluster restoration by running the following command:

```
$ oc get restores -n openshift-adp -o custom-
columns=NAME:.metadata.name,Status:.status.phase,Reason:.status.failureReason
```

Example output

```
NAME           Status      Reason
acm-klusterlet  Completed   <none> (1)
apache-app      Completed   <none>
localvolume     Completed   <none>
```

(1) The **acm-klusterlet** is specific to RHACM environments only.

Additional resources

- (Optional) Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent

15.3.3. (Optional) Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent

An automatic rollback is initiated if the upgrade does not complete within the time frame specified in the **initMonitorTimeoutSeconds** field after rebooting.

Example ImageBasedUpgrade CR

```
apiVersion: lca.openshift.io/v1
kind: ImageBasedUpgrade
metadata:
  name: upgrade
spec:
  stage: Idle
  seedImageRef:
    version: 4.15.2
    image: <seed_container_image>
  autoRollbackOnFailure: {}
#    initMonitorTimeoutSeconds: 1800 (1)
[...]
```

(1) (Optional) Specify the time frame in seconds to roll back if the upgrade does not complete within that time frame after the first reboot. If not defined or set to **0**, the default value of **1800** seconds (30 minutes) is used.

You can manually roll back the changes if you encounter unresolvable issues after an upgrade.

Prerequisites

- Log in to the hub cluster as a user with **cluster-admin** privileges.

Procedure

1. To move to the rollback stage, patch the value of the **stage** field to **Rollback** in the **ImageBasedUpgrade** CR by running the following command:

   ```
   $ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Rollback"}}' -
   -type=merge
   ```

   The Lifecycle Agent reboots the cluster with the previously installed version of OpenShift Container Platform and restores the applications.

2. If you are satisfied with the changes, finalize the rollback by patching the value of the **stage** field to **Idle** in the **ImageBasedUpgrade** CR by running the following command:

   ```
   $ oc patch imagebasedupgrades.lca.openshift.io upgrade -p='{"spec": {"stage": "Idle"}}' --
   type=merge -n openshift-lifecycle-agent
   ```

   WARNING

   If you move to the **Idle** stage after a rollback, the Lifecycle Agent cleans up resources that can be used to troubleshoot a failed upgrade.

15.3.4. Troubleshooting image-based upgrades with Lifecycle Agent

You can encounter issues during the image-based upgrade.

15.3.4.1. Collecting logs

You can use the **oc adm must-gather** CLI to collect information for debugging and troubleshooting.

Procedure

- Collect data about the Operators by running the following command:

  ```
  $  oc adm must-gather \
  --dest-dir=must-gather/tmp \
  --image=$(oc -n openshift-lifecycle-agent get deployment.apps/lifecycle-agent-controller-
  manager -o jsonpath='{.spec.template.spec.containers[?(@.name == "manager")].image}') \
  --image=quay.io/konveyor/oadp-must-gather:latest \ 1
  --image=quay.io/openshift/origin-must-gather:latest 2
  ```

  1 (Optional) You can add this options if you need to gather more information from the OADP Operator.

  2 (Optional) You can add this options if you need to gather more information from the SR-IOV Operator.

IOV Operator

15.3.4.2. AbortFailed or FinalizeFailed error

Issue

During the finalize stage or when you stop the process at the **Prep** stage, Lifecycle Agent cleans up the following resources:

- Stateroot that is no longer required
- Precaching resources
- OADP CRs
- **ImageBasedUpgrade** CR

If the Lifecycle Agent fails to perform the above steps, it transitions to the **AbortFailed** or **FinalizeFailed** states. The condition message and log show which steps failed.

Example error message

```
message: failed to delete all the backup CRs. Perform cleanup manually then add
'lca.openshift.io/manual-cleanup-done' annotation to ibu CR to transition back to Idle
      observedGeneration: 5
      reason: AbortFailed
      status: "False"
      type: Idle
```

Resolution

1. Inspect the logs to determine why the failure occurred.
2. To prompt Lifecycle Agent to retry the cleanup, add the **lca.openshift.io/manual-cleanup-done** annotation to the **ImageBasedUpgrade** CR.
   After observing this annotation, Lifecycle Agent retries the cleanup and, if it is successful, the **ImageBasedUpgrade** stage transitions to **Idle**.

   If the cleanup fails again, you can manually clean up the resources.

15.3.4.2.1. Cleaning up stateroot manually

Issue

Stopping at the **Prep** stage, Lifecycle Agent cleans up the new stateroot. When finalizing after a successful upgrade or a rollback, Lifecycle Agent cleans up the old stateroot. If this step fails, it is recommended that you inspect the logs to determine why the failure occurred.

Resolution

1. Check if there are any existing deployments in the stateroot by running the following command:

   ```
   $ ostree admin status
   ```

2. If there are any, clean up the existing deployment by running the following command:

```
$ ostree admin undeploy <index_of_deployment>
```

3. After cleaning up all the deployments of the stateroot, wipe the stateroot directory by running the following commands:

   > **WARNING**
   >
   > Ensure that the booted deployment is not in this stateroot.

   ```
   $ stateroot="<stateroot_to_delete>"
   ```

   ```
   $ unshare -m /bin/sh -c "mount -o remount,rw /sysroot && rm -rf
   /sysroot/ostree/deploy/${stateroot}"
   ```

15.3.4.2.2. Cleaning up OADP resources manually

Issue

Automatic cleanup of OADP resources can fail due to connection issues between Lifecycle Agent and the S3 backend. By restoring the connection and adding the **lca.openshift.io/manual-cleanup-done** annotation, the Lifecycle Agent can successfully cleanup backup resources.

Resolution

1. Check the backend connectivity by running the following command:

   ```
   $ oc get backupstoragelocations.velero.io -n openshift-adp
   ```

   Example output

   ```
   NAME                          PHASE       LAST VALIDATED   AGE   DEFAULT
   dataprotectionapplication-1   Available   33s              8d    true
   ```

2. Remove all backup resources and then add the **lca.openshift.io/manual-cleanup-done** annotation to the **ImageBasedUpgrade** CR.

15.3.4.3. LVM Storage volume contents not restored

When LVM Storage is used to provide dynamic persistent volume storage, LVM Storage might not restore the persistent volume contents if it is configured incorrectly.

15.3.4.3.1. Missing LVM Storage-related fields in Backup CR

Issue

Your **Backup** CRs might be missing fields that are needed to restore your persistent volumes. You can check for events in your application pod to determine if you have this issue by running the following:

```
$ oc describe pod <your_app_name>
```

Example output showing missing LVM Storage-related fields in Backup CR

```
Events:
  Type     Reason            Age                From               Message
  ----     ------            ----               ----               -------
  Warning  FailedScheduling  58s (x2 over 66s)  default-scheduler  0/1 nodes are available: pod has unbound immediate PersistentVolumeClaims. preemption: 0/1 nodes are available: 1 Preemption is not helpful for scheduling..
  Normal   Scheduled         56s                default-scheduler  Successfully assigned default/db-1234 to sno1.example.lab
  Warning  FailedMount       24s (x7 over 55s)  kubelet            MountVolume.SetUp failed for volume "pvc-1234" : rpc error: code = Unknown desc = VolumeID is not found
```

Resolution

You must include **logicalvolumes.topolvm.io** in the application **Backup** CR. Without this resource, the application restores its persistent volume claims and persistent volume manifests correctly, however, the **logicalvolume** associated with this persistent volume is not restored properly after pivot.

Example Backup CR

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: small-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  includedClusterScopedResources: (1)
  - persistentVolumes
  - volumesnapshotcontents
  - logicalvolumes.topolvm.io
```

(1) To restore the persistent volumes for your application, you must configure this section as shown.

15.3.4.3.2. Missing LVM Storage-related fields in Restore CR

Issue

The expected resources for the applications are restored but the persistent volume contents are not preserved after upgrading.

1. List the persistent volumes for you applications by running the following command before pivot:

```
$ oc get pv,pvc,logicalvolumes.topolvm.io -A
```

Example output before pivot

```
NAME                        CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS
CLAIM            STORAGECLASS   REASON   AGE
persistentvolume/pvc-1234   1Gi        RWO            Retain           Bound    default/pvc-db
lvms-vg1                4h45m

NAMESPACE   NAME                          STATUS   VOLUME     CAPACITY   ACCESS
MODES   STORAGECLASS   AGE
default     persistentvolumeclaim/pvc-db   Bound    pvc-1234   1Gi        RWO            lvms-
vg1       4h45m

NAMESPACE   NAME                               AGE
            logicalvolume.topolvm.io/pvc-1234   4h45m
```

2. List the persistent volumes for you applications by running the following command after pivot:

```
$ oc get pv,pvc,logicalvolumes.topolvm.io -A
```

Example output after pivot

```
NAME                        CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS
CLAIM            STORAGECLASS   REASON   AGE
persistentvolume/pvc-1234   1Gi        RWO            Delete           Bound    default/pvc-db
lvms-vg1                19s

NAMESPACE   NAME                          STATUS   VOLUME     CAPACITY   ACCESS
MODES   STORAGECLASS   AGE
default     persistentvolumeclaim/pvc-db   Bound    pvc-1234   1Gi        RWO            lvms-
vg1       19s

NAMESPACE   NAME                               AGE
            logicalvolume.topolvm.io/pvc-1234   18s
```

Resolution

The reason for this issue is that the **logicalvolume** status is not preserved in the **Restore** CR. This status is important because it is required for Velero to reference the volumes that must be preserved after pivoting. You must include the following fields in the application **Restore** CR:

Example Restore CR

```
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: sample-vote-app
  namespace: openshift-adp
  labels:
      velero.io/storage-location: default
    annotations:
      lca.openshift.io/apply-wave: "3"
  spec:
    backupName:
      sample-vote-app
    restorePVs: true (1)
    restoreStatus: (2)
      includedResources:
        - logicalvolumes
```

(1) To preserve the persistent volumes for your application, you must set **restorePVs** to **true**.

(2) To preserve the persistent volumes for your application, you must configure this section as shown.

15.3.4.4. Debugging failed Backup and Restore CRs

Issue

The backup or restoration of artifacts failed.

Resolution

You can debug **Backup** and **Restore** CRs and retrieve logs with the Velero CLI tool. The Velero CLI tool provides more detailed information than the OpenShift CLI tool.

1. Describe the **Backup** CR that contains errors by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero describe backup
-n openshift-adp backup-acm-klusterlet --details
```

2. Describe the **Restore** CR that contains errors by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero describe restore
-n openshift-adp restore-acm-klusterlet --details
```

3. Download the backed up resources to a local directory by running the following command:

```
$ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero backup
download -n openshift-adp backup-acm-klusterlet -o ~/backup-acm-klusterlet.tar.gz
```

15.4. PERFORMING AN IMAGE-BASED UPGRADE FOR SINGLE-NODE OPENSHIFT CLUSTERS USING GITOPS ZTP

You can upgrade your managed single-node OpenShift cluster with the image-based upgrade through GitOps Zero Touch Provisioning (ZTP).

When you deploy the Lifecycle Agent on a cluster, an **ImageBasedUpgrade** CR is automatically created. You update this CR to specify the image repository of the seed image and to move through the different stages.

15.4.1. Moving to the Prep stage of the image-based upgrade with Lifecycle Agent and GitOps ZTP

When you deploy the Lifecycle Agent on a cluster, an **ImageBasedUpgrade** CR is automatically created. You update this CR to specify the image repository of the seed image and to move through the different stages.

Prerequisites

- Create policies and **ConfigMap** objects for resources used in the image-based upgrade. For more information, see "Creating ConfigMap objects for the image-based upgrade with GitOps ZTP

Procedure

1. Add policies for the **Prep**, **Upgrade**, and **Idle** stages to your existing group **PolicyGenTemplate** called **ibu-upgrade-ranGen.yaml**:

```
apiVersion: ran.openshift.io/v1
kind: PolicyGenTemplate
metadata:
  name: example-group-ibu
  namespace: "ztp-group"
spec:
  bindingRules:
    group-du-sno: ""
  mcp: "master"
  evaluationInterval: 1
    compliant: 10s
    noncompliant: 10s
  sourceFiles:
    - fileName: ConfigMapGeneric.yaml
      complianceType: mustonlyhave
      policyName: "oadp-cm-policy"
      metadata:
        name: oadp-cm
        namespace: openshift-adp
    - fileName: ibu/ImageBasedUpgrade.yaml
      policyName: "prep-stage-policy"
      spec:
        stage: Prep
        seedImageRef: 2
          version: "4.15.0"
          image: "quay.io/user/lca-seed:4.15.0"
          pullSecretRef:
            name: "<seed_pull_secret>"
        oadpContent: 3
        - name: "oadp-cm"
          namespace: "openshift-adp"
      status:
        conditions:
          - reason: Completed
            status: "True"
            type: PrepCompleted
            message: "Prep stage completed successfully"
    - fileName: ibu/ImageBasedUpgrade.yaml
      policyName: "upgrade-stage-policy"
      spec:
        stage: Upgrade
      status:
        conditions:
          - reason: Completed
            status: "True"
            type: UpgradeCompleted
    - fileName: ibu/ImageBasedUpgrade.yaml
      policyName: "finalize-stage-policy"
      complianceType: mustonlyhave
      spec:
        stage: Idle
    - fileName: ibu/ImageBasedUpgrade.yaml
      policyName: "finalize-stage-policy"
      status:
        conditions:
          - reason: Idle
            status: "True"
            type: Idle
```

1. The policy evaluation interval for compliant and non-compliant policies. Set them to **10s** to ensure that the policies status accurately reflects the current upgrade status.
2. Define the seed image, OpenShift Container Platform version, and pull secret for the upgrade in the Prep stage.
3. Define the OADP **ConfigMap** resources required for backup and restore.

2. Verify that the policies required for an image-based upgrade are created by running the following command:

```
$ oc get policies -n spoke1 | grep -E "example-group-ibu"
```

Example output

```
ztp-group.example-group-ibu-oadp-cm-policy      inform           NonCompliant         31h
ztp-group.example-group-ibu-prep-stage-policy        inform           NonCompliant         31h
ztp-group.example-group-ibu-upgrade-stage-policy      inform           NonCompliant
31h
ztp-group.example-group-ibu-finalize-stage-policy      inform           NonCompliant         31h
ztp-group.example-group-ibu-rollback-stage-policy     inform           NonCompliant
31h
```

3. Update the **du-profile** cluster label to the target platform version or the corresponding policy-binding label in the **SiteConfig** CR.

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
[...]
spec:
```

```
[...]
  clusterLabels:
    du-profile: "4.15.0"
```

> **IMPORTANT**
>
> Updating the labels to the target platform version unbinds the existing set of policies.

4. Commit and push the updated **SiteConfig** CR to the Git repository.

5. When you are ready to move to the **Prep** stage, create the **ClusterGroupUpgrade** CR on the target hub cluster with the **Prep** and OADP **ConfigMap** policies:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-ibu-prep
  namespace: default
spec:
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - example-group-ibu-oadp-cm-policy
  - example-group-ibu-prep-stage-policy
  remediationStrategy:
    canaries:
      - spoke1
    maxConcurrency: 1
    timeout: 240
```

6. Apply the **Prep** policy by running the following command:

```
$ oc apply -f cgu-ibu-prep.yml
```

If you provide **ConfigMap** objects for OADP resources and extra manifests, Lifecycle Agent validates the specified **ConfigMap** objects during the **Prep** stage. You might encounter the following issues:

- Validation warnings or errors if the Lifecycle Agent detects any issues with **extraManifests**

- Validation errors if the Lifecycle Agent detects any issues with **oadpContent**

Validation warnings do not block the **Upgrade** stage but you must decide if it is safe to proceed with the upgrade. These warnings, for example missing CRDs, namespaces or dry run failures, update the **status.conditions** in the **Prep** stage and **annotation** fields in the **ImageBasedUpgrade** CR with details about the warning.

Example validation warning

```
[...]
metadata:
annotations:
  extra-manifest.lca.openshift.io/validation-warning: '...'
[...]
```

However, validation errors, such as adding **MachineConfig** or Operator manifests to extra manifests, cause the **Prep** stage to fail and block the **Upgrade** stage.

When the validations pass, the cluster creates a new **ostree** stateroot, which involves pulling and unpacking the seed image, and running host level commands. Finally, all the required images are precached on the target cluster.

7. Monitor the status and wait for the **cgu-ibu-prep ClusterGroupUpgrade** to report **Completed** by running the following command:

```
$ oc get cgu -n default
```

Example output

```
NAME             AGE   STATE      DETAILS
cgu-ibu-prep      31h   Completed   All clusters are compliant with all the managed policies
```

Additional resources

- Preparing the GitOps ZTP site configuration repository for version independence
- Creating ConfigMap objects for the image-based upgrade with Lifecycle Agent using GitOps ZTP
- Configuring a shared container directory between ostree stateroots when using GitOps ZTP
- About backup and snapshot locations and their secrets
- Creating a Backup CR
- Creating a Restore CR

15.4.2. Moving to the Upgrade stage of the image-based upgrade with Lifecycle Agent and GitOps ZTP

After you completed the **Prep** stage, you can upgrade the target cluster. During the upgrade process, the OADP Operator creates a backup of the artifacts specified in the OADP CRs, then the Lifecycle Agent upgrades the cluster.

If the upgrade fails or stops, an automatic rollback is initiated. If you have an issue after the upgrade, you can initiate a manual rollback. For more information about manual rollback, see "(Optional) Initiating a rollback with Lifecycle Agent and GitOps ZTP".

Prerequisites

- Complete the **Prep** stage.

Procedure

1. When you are ready to move to the **Upgrade** stage, create the **ClusterGroupUpgrade** CR on the target hub cluster that references the **Upgrade** policy:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-ibu-upgrade
  namespace: default
spec:
  actions:
    beforeEnable:
      addClusterAnnotations:
        import.open-cluster-management.io/disable-auto-import: "true" (1)
    afterCompletion:
      removeClusterAnnotations:
      - import.open-cluster-management.io/disable-auto-import (2)
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - example-group-ibu-upgrade-stage-policy
  remediationStrategy:
    canaries:
      - spoke1
    maxConcurrency: 1
    timeout: 240
```

1. Applies the **disable-auto-import** annotation to the managed cluster before starting the upgrade. This annotation ensures the automatic importing of managed cluster is disabled during the upgrade stage until the cluster is ready.

2. Removes the **disable-auto-import** annotation after the upgrade is complete.

2. Apply the **Upgrade** policy by running the following command:

```
$ oc apply -f cgu-ibu-upgrade.yml
```

3. Monitor the status by running the following command and wait for the **cgu-ibu-upgrade ClusterGroupUpgrade** to report **Completed**:

```
$ oc get cgu -n default
```

Example output

```
NAME                  AGE   STATE       DETAILS
cgu-ibu-prep          31h   Completed   All clusters are compliant with all the managed policies
cgu-ibu-upgrade       31h   Completed   All clusters are compliant with all the managed
policies
```

4. When you are satisfied with the changes and ready to finalize the upgrade, create a **ClusterGroupUpgrade** CR on target hub cluster that references the policy that finalizes the upgrade:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-ibu-finalize
  namespace: default
spec:
  actions:
    beforeEnable:
      removeClusterAnnotations:
      - import.open-cluster-management.io/disable-auto-import
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - example-group-ibu-finalize-stage-policy
  remediationStrategy:
    canaries:
      - spoke1
    maxConcurrency: 1
    timeout: 240
```

IMPORTANT

Ensure that no other **ClusterGroupUpgrade** CRs are in progress because this causes TALM to continuously reconcile them. Delete all **"In-Progress" ClusterGroupUpgrade** CRs before applying the **cgu-ibu-finalize.yaml**.

5. Apply the policy by running the following command:

```
$ oc apply -f cgu-ibu-finalize.yaml
```

6. Monitor the status by running the following command: and wait for the **cgu-ibu-finalize ClusterGroupUpgrade** to report **Completed**:

```
$ oc get cgu -n default
```

Example output

```
NAME               AGE   STATE       DETAILS
cgu-ibu-finalize     30h   Completed   All clusters are compliant with all the managed policies
cgu-ibu-prep         31h   Completed   All clusters are compliant with all the managed policies
cgu-ibu-upgrade        31h   Completed   All clusters are compliant with all the managed
policies
```

Additional resources

- (Optional) Moving to the Rollback stage of the image-based upgrade with Lifecycle Agent and GitOps ZTP

15.4.3. (Optional) Moving to the Rollback stage with Lifecycle Agent and GitOps ZTP

If you encounter an issue after upgrade, you can start a manual rollback.

Procedure

1. Revert the **du-profile** or the corresponding policy-binding label to the original platform version in the **SiteConfig** CR:

```
apiVersion: ran.openshift.io/v1
kind: SiteConfig
[...]
spec:
  [...]
    clusterLabels:
      du-profile: "4.14.x"
```

2. When you are ready to initiate the rollback, add the **Rollback** policy to your existing group **PolicyGenTemplate** CR:

```
[...]
- fileName: ibu/ImageBasedUpgrade.yaml
  policyName: "rollback-stage-policy"
  spec:
    stage: Rollback
  status:
    conditions:
      - message: Rollback completed
        reason: Completed
        status: "True"
        type: RollbackCompleted
```

3. Create a **ClusterGroupUpgrade** CR on target hub cluster that references the **Rollback** policy:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-ibu-rollback
  namespace: default
spec:
  actions:
    beforeEnable:
      removeClusterAnnotations:
      - import.open-cluster-management.io/disable-auto-import
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - example-group-ibu-rollback-stage-policy
  remediationStrategy:
    canaries:
      - spoke1
    maxConcurrency: 1
    timeout: 240
```

4. Apply the **Rollback** policy by running the following command:

```
$ oc apply -f cgu-ibu-rollback.yml
```

5. When you are satisfied with the changes and you are ready to finalize the rollback, create a **ClusterGroupUpgrade** CR on target hub cluster that references the policy that finalizes the rollback:

```
apiVersion: ran.openshift.io/v1alpha1
kind: ClusterGroupUpgrade
metadata:
  name: cgu-ibu-finalize
  namespace: default
spec:
  actions:
    beforeEnable:
      removeClusterAnnotations:
      - import.open-cluster-management.io/disable-auto-import
  clusters:
  - spoke1
  enable: true
  managedPolicies:
  - example-group-ibu-finalize-stage-policy
  remediationStrategy:
    canaries:
      - spoke1
    maxConcurrency: 1
    timeout: 240
```

6. Apply the policy by running the following command:

```
$ oc apply -f cgu-ibu-finalize.yml
```

15.4.4. Troubleshooting image-based upgrades with Lifecycle Agent

You can encounter issues during the image-based upgrade.

15.4.4.1. Collecting logs

You can use the **oc adm must-gather** CLI to collect information for debugging and troubleshooting.

Procedure

- Collect data about the Operators by running the following command:

```
$  oc adm must-gather \
--dest-dir=must-gather/tmp \
--image=$(oc -n openshift-lifecycle-agent get deployment.apps/lifecycle-agent-controller-
manager -o jsonpath='{.spec.template.spec.containers[?(@.name == "manager")].image}') \
--image=quay.io/konveyor/oadp-must-gather:latest \ 1
--image=quay.io/openshift/origin-must-gather:latest 2
```

1 (Optional) You can add this options if you need to gather more information from the OADP Operator.

2 (Optional) You can add this options if you need to gather more information from the SR-IOV Operator.

15.4.4.2. AbortFailed or FinalizeFailed error

Issue

During the finalize stage or when you stop the process at the **Prep** stage, Lifecycle Agent cleans up the following resources:

- Stateroot that is no longer required
- Precaching resources
- OADP CRs
- **ImageBasedUpgrade** CR

If the Lifecycle Agent fails to perform the above steps, it transitions to the **AbortFailed** or **FinalizeFailed** states. The condition message and log show which steps failed.

Example error message

```
message: failed to delete all the backup CRs. Perform cleanup manually then add
'lca.openshift.io/manual-cleanup-done' annotation to ibu CR to transition back to Idle
    observedGeneration: 5
    reason: AbortFailed
    status: "False"
    type: Idle
```

Resolution

1. Inspect the logs to determine why the failure occurred.
2. To prompt Lifecycle Agent to retry the cleanup, add the **lca.openshift.io/manual-cleanup-done** annotation to the **ImageBasedUpgrade** CR.
   After observing this annotation, Lifecycle Agent retries the cleanup and, if it is successful, the **ImageBasedUpgrade** stage transitions to **Idle**.

   If the cleanup fails again, you can manually clean up the resources.

15.4.4.2.1. Cleaning up stateroot manually

Issue

Stopping at the **Prep** stage, Lifecycle Agent cleans up the new stateroot. When finalizing after a successful upgrade or a rollback, Lifecycle Agent cleans up the old stateroot. If this step fails, it is recommended that you inspect the logs to determine why the failure occurred.

Resolution

1. Check if there are any existing deployments in the stateroot by running the following command:

   ```
   $ ostree admin status
   ```

2. If there are any, clean up the existing deployment by running the following command:

   ```
   $ ostree admin undeploy <index_of_deployment>
   ```

3. After cleaning up all the deployments of the stateroot, wipe the stateroot directory by running the following commands:

   > **WARNING**
   >
   > Ensure that the booted deployment is not in this stateroot.

   ```
   $ stateroot="<stateroot_to_delete>"
   ```

   ```
   $ unshare -m /bin/sh -c "mount -o remount,rw /sysroot && rm -rf
   /sysroot/ostree/deploy/${stateroot}"
   ```

15.4.4.2.2. Cleaning up OADP resources manually

Issue

Automatic cleanup of OADP resources can fail due to connection issues between Lifecycle Agent and the S3 backend. By restoring the connection and adding the **lca.openshift.io/manual-cleanup-done** annotation, the Lifecycle Agent can successfully cleanup backup resources.

Resolution

1. Check the backend connectivity by running the following command:

   ```
   $ oc get backupstoragelocations.velero.io -n openshift-adp
   ```

   Example output

   ```
   NAME                          PHASE       LAST VALIDATED   AGE   DEFAULT
   dataprotectionapplication-1   Available   33s              8d    true
   ```

2. Remove all backup resources and then add the **lca.openshift.io/manual-cleanup-done** annotation to the **ImageBasedUpgrade** CR.

15.4.4.3. LVM Storage volume contents not restored

When LVM Storage is used to provide dynamic persistent volume storage, LVM Storage might not restore the persistent volume contents if it is configured incorrectly.

15.4.4.3.1. Missing LVM Storage-related fields in Backup CR

Issue

Your **Backup** CRs might be missing fields that are needed to restore your persistent volumes. You can check for events in your application pod to determine if you have this issue by running the following:

```
$ oc describe pod <your_app_name>
```

Example output showing missing LVM Storage-related fields in Backup CR

```
Events:
  Type    Reason           Age               From              Message
  ----    ------           ----              ----              -------
  Warning  FailedScheduling  58s (x2 over 66s)  default-scheduler  0/1 nodes are available: pod
has unbound immediate PersistentVolumeClaims. preemption: 0/1 nodes are available: 1
Preemption is not helpful for scheduling..
  Normal   Scheduled         56s               default-scheduler  Successfully assigned default/db-1234
to sno1.example.lab
  Warning  FailedMount       24s (x7 over 55s)  kubelet           MountVolume.SetUp failed for
volume "pvc-1234" : rpc error: code = Unknown desc = VolumeID is not found
```

Resolution

You must include **logicalvolumes.topolvm.io** in the application **Backup** CR. Without this resource, the application restores its persistent volume claims and persistent volume manifests correctly, however, the **logicalvolume** associated with this persistent volume is not restored properly after pivot.

Example Backup CR

```
apiVersion: velero.io/v1
kind: Backup
metadata:
  labels:
    velero.io/storage-location: default
  name: small-app
  namespace: openshift-adp
spec:
  includedNamespaces:
  - test
  includedNamespaceScopedResources:
  - secrets
  - persistentvolumeclaims
  - deployments
  - statefulsets
  includedClusterScopedResources: (1)
  - persistentVolumes
  - volumesnapshotcontents
  - logicalvolumes.topolvm.io
```

(1) To restore the persistent volumes for your application, you must configure this section as shown.

15.4.4.3.2. Missing LVM Storage-related fields in Restore CR

Issue

The expected resources for the applications are restored but the persistent volume contents are not preserved after upgrading.

1. List the persistent volumes for you applications by running the following command before pivot:

```
$ oc get pv,pvc,logicalvolumes.topolvm.io -A
```

Example output before pivot

```
NAME                        CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS
CLAIM            STORAGECLASS   REASON   AGE
persistentvolume/pvc-1234   1Gi        RWO            Retain           Bound    default/pvc-db
lvms-vg1                4h45m

NAMESPACE   NAME                          STATUS   VOLUME     CAPACITY   ACCESS
MODES   STORAGECLASS   AGE
default     persistentvolumeclaim/pvc-db   Bound    pvc-1234   1Gi        RWO            lvms-
vg1       4h45m

NAMESPACE   NAME                                 AGE
            logicalvolume.topolvm.io/pvc-1234   4h45m
```

2. List the persistent volumes for you applications by running the following command after pivot:

```
$ oc get pv,pvc,logicalvolumes.topolvm.io -A
```

Example output after pivot

```
NAME                        CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS
CLAIM            STORAGECLASS   REASON   AGE
persistentvolume/pvc-1234   1Gi        RWO            Delete           Bound    default/pvc-db
lvms-vg1                19s

NAMESPACE   NAME                          STATUS   VOLUME     CAPACITY   ACCESS
MODES   STORAGECLASS   AGE
default     persistentvolumeclaim/pvc-db   Bound    pvc-1234   1Gi        RWO            lvms-
vg1       19s

NAMESPACE   NAME                                 AGE
            logicalvolume.topolvm.io/pvc-1234   18s
```

Resolution

The reason for this issue is that the **logicalvolume** status is not preserved in the **Restore** CR. This status is important because it is required for Velero to reference the volumes that must be preserved after pivoting. You must include the following fields in the application **Restore** CR:

Example Restore CR

```
apiVersion: velero.io/v1
kind: Restore
metadata:
  name: sample-vote-app
  namespace: openshift-adp
  labels:
    velero.io/storage-location: default
  annotations:
    lca.openshift.io/apply-wave: "3"
```

```
spec:
  backupName:
    sample-vote-app
  restorePVs: true (1)
  restoreStatus: (2)
    includedResources:
      - logicalvolumes
```

(1) To preserve the persistent volumes for your application, you must set **restorePVs** to **true**.

(2) To preserve the persistent volumes for your application, you must configure this section as shown.

15.4.4.4. Debugging failed Backup and Restore CRs

Issue

The backup or restoration of artifacts failed.

Resolution

You can debug **Backup** and **Restore** CRs and retrieve logs with the Velero CLI tool. The Velero CLI tool provides more detailed information than the OpenShift CLI tool.

1. Describe the **Backup** CR that contains errors by running the following command:

   ```
   $ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero describe backup
   -n openshift-adp backup-acm-klusterlet --details
   ```

2. Describe the **Restore** CR that contains errors by running the following command:

   ```
   $ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero describe restore
   -n openshift-adp restore-acm-klusterlet --details
   ```

3. Download the backed up resources to a local directory by running the following command:

   ```
   $ oc exec -n openshift-adp velero-7c87d58c7b-sw6fc -c velero -- ./velero backup
   download -n openshift-adp backup-acm-klusterlet -o ~/backup-acm-klusterlet.tar.gz
   ```